INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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You May Have Conditions Like These in Your Plant, Too—

That a thorough testing will ferret out and save you a whole lot of future worries

FELLOWS, I've just received a fine letter from C. H. Funderburg, with the Woodward Iron Company at Woodward, Ala. It carries two points that I want to pass on to you. First, the best way to cure troubles is to chase them to their source and find them before they spread. Second, Mr. Funderburg works with his head as well as his hands. His letter follows:

I was very much interested in the article on pages 331 to 334 of the July issue of INDUSTRIAL ENGINEER on testing motors. For the past few weeks I have been testing motors for a mining company by which I am employed.

The mines are well equipped with proper sizes of motors, most of which operate at 3300 volts, 25 cycles. These motors are used to operate hoists, compressors, pumps and other mine machinery. Since it would have been difficult to carry transformers for a watt-hour meter through a mine with a pitching seam we used a graphic ammeter in making the tests.

The original idea was to determine the cycle of operation of the hoist motors. There are five 700-hp. hoist motors, three 500-hp. hoist motors, two 200-hp. hoist motors and several smaller hoist motors, all of the slip-ring, induction type.

To our surprise the tests not only furnished the cycle of operation but showed defects in the driving mechanism. On one 700-hp. hoist motor the graphic chart showed a swing of the needle at regular intervals. Upon noticing this I began to look for the trouble and found that it was due to a high spot on the brake drum, which rubbed on the brake band each revolution of the drum. See chart No. 1.

One of the air compressors driven by a 700-hp. motor had a bad gear. This gear did not make any noise but I found that for every revolution of this gear there was a distinct swing of the needle. See chart No. 2. One week later this gear went to pieces but the findings from the test gave us time to have another made.

In testing a motor on one of the centrifugal pumps, the chart showed that the pump had regular intervals of pumping and churning the water. See chart No. 3. The tests on several other motors showed troubles in the driving mechanism that would not have been normally noticed.

Mr. Funderburg has illustrated exactly what we mean when we say that INDUSTRIAL ENGINEER is devoted to the maintenance and operation of electrical and associated mechanical systems. In many cases the troubles that show up in a piece of electrical equipment are located outside that equipment, in the machines they operate, and the way to cure many troubles that are found in electrical apparatus is to hunt them down to their source. Simply taking a damaged motor out of service for repairs and replacing it by another does not do the trick. Do you get the point?

The real trouble may be upstairs, downstairs, or somewhere else along the line and it is more apt to be mechanical than electrical.

Practical Pete

A Glimpse Into the Works of

E. I. du Pont de Nemours and Company

Where a large group of dissimilar products are produced through the development and extension of related industrial processes. The eighth of a series devoted to the growth and extent of our basic American industries.

THE NAME of E. I du Pont de Nemours and Company is chiefly associated with the manufacture of explosives, although at the present time it produces in addition a large group of dissimilar products. It has been engaged in the production of these basic materials since 1802 when E. I. du Pont de Nemours, then a young man 28 years of age, came to the United States from France and established his first powder mill near Wilmington, Del.

He was helped by Thomas Jefferson, and others who saw the great advantage of having the United States independent in its supply of gunpowder. Among his earliest consignments was powder for war against the pirates of Tripoli and the company has supplied powder in all wars since. However, the company can not be considered as a military institution, for its growth has been dependent on other industrial and commercial developments. The proportion of du Pont explosives used for military purposes before the recent war was small—about 5 per cent. The remainder, except for sporting powders, was used for industrial purposes, and was indispensable to modern industry.

During the life of the company, through the use of explosives, more than 250,000 miles of railroad and more than 2,000,000 miles of highways have been built in the United States, and in one single year more than 600,000,000 tons of coal have been mined. Quarries use 60,000,000 lb. of dynamite per year. About 1,000 lb. of explosives are required to produce the material required for a mile of 16-ft. road. Coal mining uses 302,000,000 lb. of explosives, other mining demands 90,000,000 lb. and agriculture requires 20,000,000 lb. of dynamite annually.

The first powder factory and office of the du Pont Company.

The oldest powder mill in the United States (upper illustration) was built by E. I. du Pont de Nemours in 1802 on the banks of the Brandywine near Wilmington, Del., to supply powder for the Government. From the beginning officers of the United States Government have worked hand in hand with the du Pont Company in the latter's laboratories, the joint efforts of all being directed toward maintaining the United States in a position of leadership in the production of the most modern and effective military powders.

The manufacture of explosives is today an important chemical industry and the ramifications of this manufacture have led the du Pont Company into related lines of industry so that it produces not only explosives, but also dyes, enamels, chemicals, paints and varnishes, pyralin (a pyroxylin product) and fabrikoid, an impervious fabric with a cloth foundation and a pyroxylin surface.

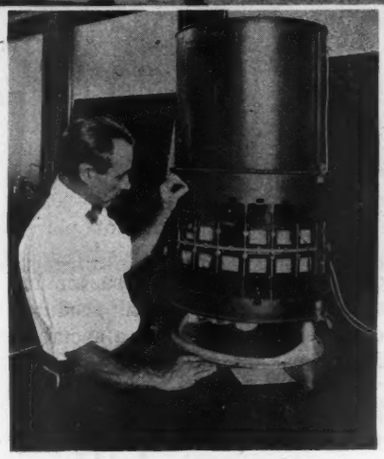
These are not by-products, but their manufacture is more or less closely related to the manufacture of explosives. This relation may rest upon identity of raw materials or intermediates and the similarity of processes and equipment required in manufacture. For example, the sporting

The Repauno dynamite works at Gibbstown, New Jersey, is the largest plant of its kind in the world.

This plant (a section of which is shown in the panorama view on this and on the opposite page) covers an area of 933 acres, with 1,400 acres additional held in reserve for isolation and possible future expansion, and has a capacity of 60,000,000 lb. of dynamite a year.

A bird's-eye view of the du Pont dyeworks at Deepwater, N. J.

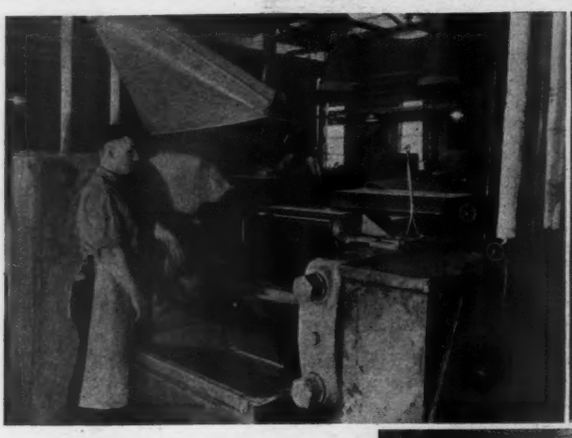
The feature of particular interest here is the widely separated buildings, generally of small size. Isolation is necessary because of the fire hazard and the explosive nature of some of the intermediate products, as certain steps in the dye-making process are quite similar to those employed in the manufacture of explosives. Before the recent war the United States was dependent upon foreign countries, largely Germany, for its dyestuffs and necessity forced American manufacturers, including the du Pont Company, to enter into their production. The importance of dyestuffs is well shown by the fact that twenty-four major industries, employing more than 1,000,000 persons and with many other industries dependent upon them, are dependent upon an uninterrupted supply of dyestuffs. A fade-ometer (to test the fastness of colors to light) is shown in the small illustration at the right.



powder used in shotguns has nitrated cellulose (cotton or other cellulose material treated with nitric acid) as one of its essential ingredients. The nitration of cellulose by slightly different methods and to varying degrees of nitration is also required for the preparation of one of the essential ingredients of photographic film, leather substitutes such as fabrikoid, enamels, pyroxylin lacquers, and the various nitrocellulose colloids such as the nitrocellulose camphor colloid, known as pyralin, which is manufactured into all sorts of useful as well as ornamental materials. While the processes of manufacture and the products obtained from these closely related lines are not identical, nevertheless the similarity is sufficient to make their common production a logical undertaking.

The relation of the manufacture of paints, varnishes and colors to explosives lies in a common interest in the production of certain so-called "heavy chemicals" although a more intimate tie exists between the paint and color industry and the so-called chemical mixture business. Also, the manufacture of colors has a close relation to the production of dyes.

Many of the chemical processes involved in the manufacture of explosives, pharmaceuticals and dyes are closely related or in some cases identical. Because of this close similarity of many of the reactions involved and the rather close relation of much of the chemistry which concerns itself with the dyes and explosives, the du Pont company found a related



Two steps in making pyralin.

In the rolling operation (above) the "colloid," as received from the mixing room, is manipulated on pairs of large steel rolls to obtain uniformity and distribution of color. Polish is imparted by placing each piece between two smooth, nickel plates and subjecting it to the proper amount of heat and pressure. This operation (at the right above) is known as press polishing. Pyralin material is tough, hard, solid and practically unbreakable and will not corrode, tarnish, decay or rust. It can be manipulated or worked in almost any way without cracking or splintering and takes a polish easily or may be left rough or dull. It can be made in any color and as clear as glass and is usable in many places where it is not desirable or practicable to use glass as in automobile curtains.

A view of part of a chemical laboratory in a dyeworks.

Extensive chemical laboratories are necessary for experimental work and for determining the quality and characteristics of the materials used in production in any of the chemical processes. Practically all of the du Pont products are made by chemically-controlled processes in the sixty plants operated.

field of expansion in the development of an extensive dye industry.

The manufacture of leather substitutes, such as "fabrikoid," has become a big industry. They are used in a variety of places where leather is not required or cannot be used and are an instance of how chemical products can be utilized to meet a shortage in natural supplies.

Pyroxylin plastics, like "pyralin," are another development of the American chemical industry and are finding extensive use.

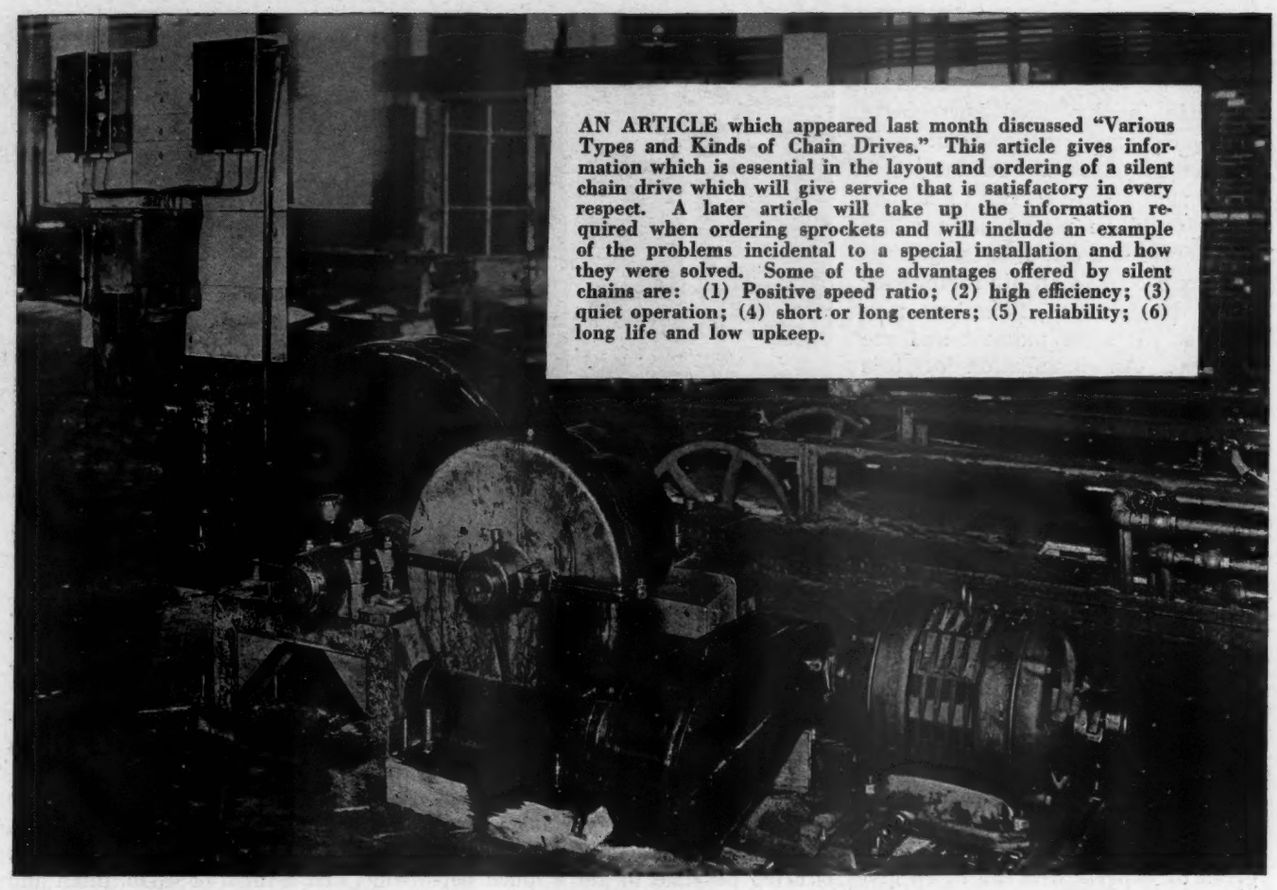
The manufacturing activities of the du Pont Company are divided into six main departments, principal products of which are: explosives, smokeless powder, dyestuffs, cellulose products, "pyralin," and paint. The improvement and better application of these products is maintained through numerous important research and technical laboratories. The Company operates about sixty plants in the United States, located with reference to markets and supplies of raw materials.

Inspecting fabrikoid, a leather substitute.

According to 1919 census, $26,282,000 worth of leather substitutes were made by seventy establishments in the United States. The majority of American-made automobiles are upholstered and trimmed with leather substitutes. Furniture manufacturers likewise use leather substitutes for upholstering. They are used in the manufacture of suit cases, briefcases, traveling bags, trunks. Millions of books are bound with them. In addition, pillows, dolls, and many article are made of leather substitutes, which are waterproof, not easily torn nor attacked by insects.

Two views in the paint works of the du Pont Company, at Philadelphia.

In the illustration at the left, the operator is grinding industrial samples of paint. The men in the laboratories make up samples of the precise color and ingredients needed for specific purposes. In the illustration below the operator is mounting, by machine, the "chips" on color cards.



AN ARTICLE which appeared last month discussed "Various Types and Kinds of Chain Drives." This article gives information which is essential in the layout and ordering of a silent chain drive which will give service that is satisfactory in every respect. A later article will take up the information required when ordering sprockets and will include an example of the problems incidental to a special installation and how they were solved. Some of the advantages offered by silent chains are: (1) Positive speed ratio; (2) high efficiency; (3) quiet operation; (4) short or long centers; (5) reliability; (6) long life and low upkeep.

Assembly conveyors in automobile factories are often operated at a speed of 1 r.p.m. or less. Here the conveyor is driven from a motor through a silent chain, a worm reduction and a gear reduction.

Some Points to Be Checked Up on

Operating Conditions Affecting Chain Service

And Taken into Account When Ordering and Installing Chains on Industrial Drives to Meet These Conditions

By FRANK E. GOODING

Associate Editor, Industrial Engineer

CHAIN DRIVES, properly selected, installed and lubricated, have operated continuously for years without giving trouble or costing a cent for repairs. With chains, as with practically any other mechanism, perfect operation is not due to good luck but results from the application of foresight and judgment in the choice and installation of the mechanism and its care when in use. One of the most important points for the industrial man to consider is the selection of a chain of the right size and type for the work to be done.

Chain manufacturers issue booklets of engineering data covering the points to consider when determining the type and style of chain that is best suited to the drive conditions. Since chain construction is not standard for all types and styles no specific information can be given that applies to all makes. When working out the first chain installation it is well to call on the manufacturer for advice and a check-up on your own estimates. As a basis for determining the proper size, the manufacturer will need the information given in the box on page 380 which outlines the service conditions surrounding the particular installation.

In discussing these points of information in sequence, the first is, of course, the horsepower to be transmitted. For this, it is always advisable to give the maximum rating of highest load which may be applied. Peak load conditions should always be considered in selecting any equipment, for that matter. If the peak load is applied only infrequently or momentarily, as at starting, the chain may be rated at maximum running load as the chain is several times stronger than the load which may be applied to it because a chain has a factor of safety of ten or more. Ultimate strength is of secondary importance as metal parts never are loaded near this breaking point. However, this does not mean that a chain may be continuously loaded above its rating with impunity.

Where shock loads are frequent, as

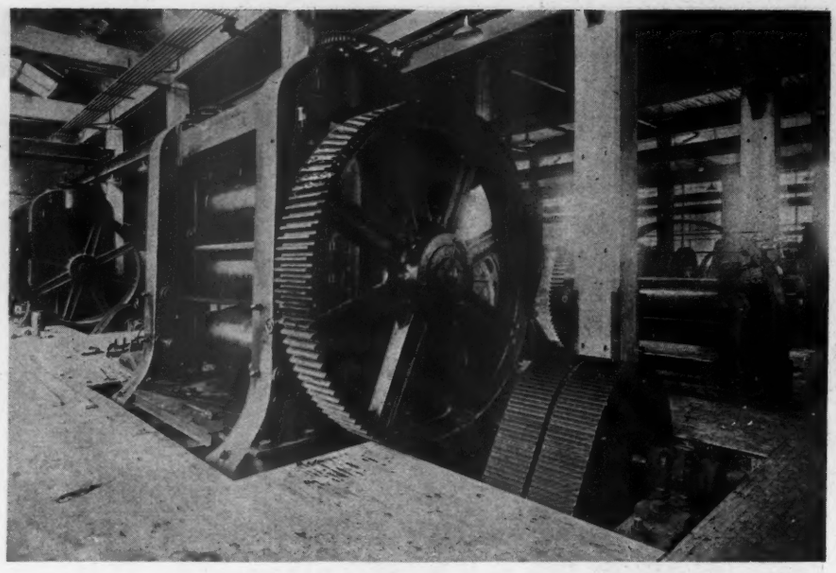
on air compressors, gas engines and similar equipment, an additional allowance of 10 to 50 per cent must be made in the rated horsepower used in determining the size of chain for the installation. Probably one of the most severe service conditions which could be placed on a silent chain drive is a one-cylinder gas engine connected to an air compressor where the pulsations from both may come at the same moment and are opposite. An installation of this type is not recommended unless provided with flywheels of adequate size to give sufficient balance and absorb the shock load.

The proper allowance to make in any shock load installation is largely a matter of experience and judgment and dependent upon the maximum momentary strains that may be developed, the frequency of their repetition and whether the full load remains for some time. Under these conditions the manufacturer of the particular type of chain selected can offer, through its engineering department, the best advice. It is always advisable to seek this consultation service because it is given by experts who can often give additional suggestions which tend toward economy in installation and operating cost.

One of the big advantages of chains is the flexibility of the center distances. Ordinarily a chain should have a distance between centers equal to the diameter of the large sprocket plus one-half the diameter of the small sprocket. It is usually best to increase this somewhat, however. Chains operated on sprockets with about 25-ft. centers or over, should be supported on idlers or better still, divided into two or more drives by using additional sprockets and shafts. Also when several parallel shafts are to be driven by one chain, it is preferable to divide the drive into shorter individual drives.

Another important factor to be considered is the speed ratio. Probably the best operating ratio is between 6- or 8-to-1 and most installations may be operated somewhere within these limits. Many installations have been operated successfully at much higher ratios, however, where the chain speed is not excessive. It is better to use a lower speed motor or other driving mechanism than to try to make excessive reductions through chain drives.

Unless an exact speed ratio is absolutely necessary, it is best to indicate how much variation is permissible. A slight variation does not make any great difference and it is often possible to get a much better selection of sprockets without using one with an extra small number of teeth, or using a chain with pitch unsuited for the conditions under which it operates. If the surroundings are such as to limit the diameter or width of either sprocket, it is necessary to note these so that the manufacturer will not recommend a size which could not be installed.



A 300-hp. chain drive installation in a rubber mill.
Here two 1½-in. pitch silent chains 14 in. wide on 96-in. centers connect the motor, which is placed in the basement, to a shaft geared to a rubber calender with a speed reduction from 600 r.p.m. to 105 r.p.m.

In choosing a chain for any installation, the user frequently has the option of several different combinations of widths and pitches. For example, a chain of ½-in. pitch, 2 in. wide, another of ⅝-in. pitch, 1½ in. wide, and a third of ¾-in. pitch and 1¼ in. wide will transmit the same power. Generally, in such cases, it is best to use a wider chain of less pitch although narrow chains of longer pitch would be somewhat cheaper. The larger sprocket may be more expensive, however. Chain

Information Necessary to Determine Proper Size of Chain Drive for Industrial Purposes

Horsepower (Maximum).....

Must speed ratio be exact?.....

	DriveR	DriveN
Rev. per min.....		
If induction motor give full speed...		
Max. sprocket dia. (including chain).		
Max. sprocket face.		
Max. shaft space available		
Diameter of shafts.		
Width and depth of keyways		
Split, yes or no....		

Make sketch showing relative positions of driveR and driveN sprockets, indicate driveR, directions of rotation and floor line.

Number of hours service per day....
How much of time at full load?....

Distance between centers of shafts.. .....

Can centers be adjusted?.....

If so, how much?.....

If not adjustable, can centers be set to suit an even number of links in the chain?.....

The chain drives from { Electric Motor / Gas Engine / Lineshaft / Steam Engine / Water Wheels } to

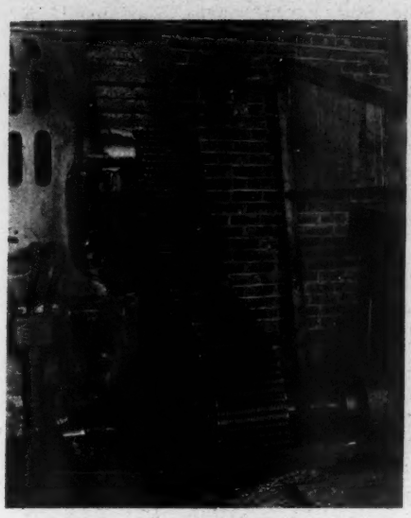
Will it be used in a dry, wet, dusty or gritty place?.....

Is the chain pull steady or pulsating? .....

If compressor, pump or gas engine, give number of impulses per revolution.....

Does drive reverse? .....

If drive replaces gears, belts or other chains give complete description of same.....



A 150-hp. motor connects a line-shaft to a copper wire drawing bench.

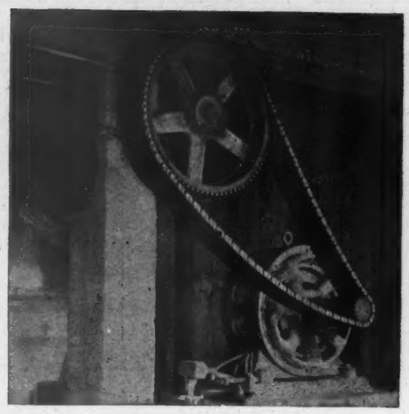
Transmission is made by a 1½-in. pitch silent chain 13 in. wide from a motor operating at 600 r.p.m. The line-shaft operates at 137 r.p.m.; this is obtained through 19 teeth in the motor pinion and 83 teeth in the sprocket.

widths of from 2 to 6 times the pitch are recommended. As dependability and low operating costs are the principal factors in chains, as in any other mechanical or electrical installation, rated capacity, speed or other operating limitations should not be exceeded in an attempt to economize in first cost.

To obtain extremely quiet operation as is required in schools, churches, offices, and similar places, wide chains of short pitch are used on sprocket wheels of not less than 17 to 23 teeth and at a lower chain speed and revolutions per minute than is ordinarily rated for the power transmitted.

Motors connected by chain drives should always be mounted on adjustable baseplates to permit the adjusting of the center distance to take up any slight wear or elongation of the links and also to permit of sufficient adjustment so that an even number of links may be used without permitting too much slack. When center distances are fixed or on vertical drives, it is some times necessary to use a "hunting" or "offset" link—a special link where three links replace four and make an odd number of links or pitches thus shortening the chain by one pitch. It is not possible to get a fractional pitch. Also chains should not be installed so short that they make tension on both sides when idle because it is never necessary and also is hard on the bearings. One of the advantages of chain drives is the freedom of an extra tension, merely to give traction, in addition to the tension arising from the pull due to transmitting power. When idle, the only tension on the chains and bearings should be the small amount due to the weight of the chain.

If a chain drive is to replace another drive a careful description of the former conditions will serve as a check on specifications and service conditions on the installation. However, if the new installation is to have increased power, higher speed, or other changes in the service conditions such facts might well be noted in addition to the other description. It is also well to show the relative position of the sprocket with respect to the floor line as special considerations must be taken into account on vertical drives, particularly if the small sprocket is below. Also it is well to note in this drawing any shafts or other projections which might interfere with the operation of the chain.

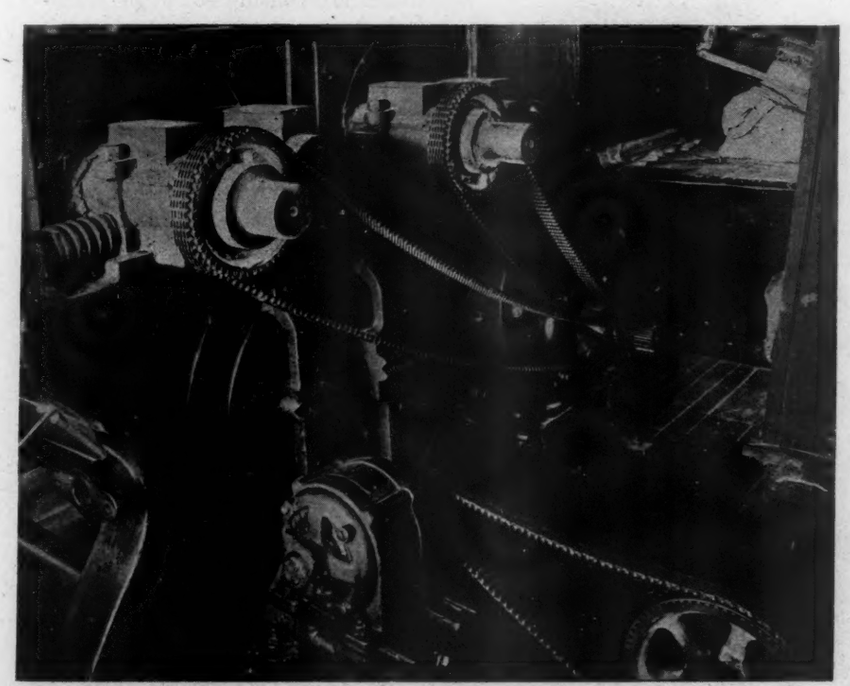


A motor connected to an overhead shaft in a mill installation.

When the large driven sprocket is placed above the smaller pinion provision must be made so that any wear or slack may be taken care of. Ordinarily this may be done by adjustable base plates or by removing a link from the chain.

When ordering a new chain to replace an old one it is not sufficient, usually, to count the links and order the same number of links in the new chain. For example, suppose a chain originally 100 links long has elongated 1 or 2 per cent during its life so that one or two links have been removed. If a new chain is ordered 98 or 99 links long, the length of the present installation, instead of 100 links long, it will be too short and necessitate a re-order. Complete information must be given on even a re-order so that the required length may be calculated as a check on the specifications listed in the order.

In order to select the most economical chain drive for any particular installation the several possible combinations of different speeds of motor with different sizes of chains and pinions must be considered. A good example to bring this point out is the following case given by Eustace C. Soares,, Electrical Engineer,



Three silent chains in an elevator installation.

Here two chains driven from the same motor pinion are attached to different shafts in an elevator mill. In this way it is possible to get absolute speed relationship in the operation of the two shafts without extensive gearing. The small chain in the lower part of the picture drives an elevating conveyor.

Cost of 7½ H. P. Motor and Chain Drive When Motors That Operate at Different Speeds Are Used

Motor Speed, R. P. M.	Number of Teeth		Cost		
	Motor Pinion	Pump Pinion	Motor	Pinions and Chain	Total
600	17	69	$325	$ 59	$384
720	17	81	275	70	345
900	17	102	265	78	343
1,200	17	135	239	107	346

Ophuls and Hill, Inc., New York City, of a motor-driven pump which was recently installed in an ice plant in New York.

In this connection it may be well first to say something about the conditions which led to the selection of chain drive. The pump, which is shown in an accompanying illustration, was originally driven by a direct-current motor direct connected to a 6-to-1 ratio geared shaft.

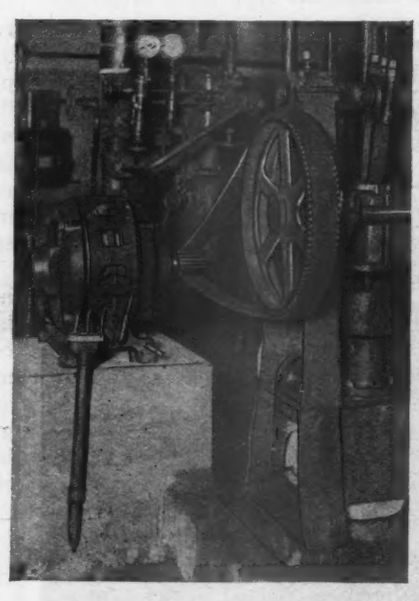
The motor was rated at 15 hp., 400 r.p.m., although the actual power required to drive the pump was about 6 hp. As the motor speed was too high, resistance was introduced in the armature circuit to reduce the speed. This was, of course, very inefficient.

The duty of this pump was to pump liquid from a receiver into a circulating system. At times the pump would do no work while at other times it would be doing its full work. If the pump was running under full load and the load went off the speed would increase about 100 per cent. Should the load come on again water hammer would be produced which might become serious. This drive was, therefore, objectionable on account of the large amount of attention required.

It became necessary to convert this drive to alternating current. Three types of drive were open for consideration; (1) direct drive, (2) belt drive with or without an idler and (3) chain drive. Direct drive was out of the question as it would be necessary for the motor to run under 200 r.p.m.; belt drive, while cheap, would not have been in keeping with the appearance of the other equipment.

Chain drive was finally decided on. Here the question of the speed of the motor came in because the higher the speed of the motor for the same horsepower the cheaper the price. First, a minimum limit of a 17-tooth pinion was fixed for the motor to insure a satisfactory drive. This point being decided it was then necessary to determine the size of the driven pinion mounted on the pump. With increasing size of this pinion the permissible speed of the motor increases and the price of the motor decreases. However, a limiting point is reached where the increased cost of the large pinion is more than the decreasing cost of the motor and *vice versa*. The balance between these costs was worked out for several different speeds of motor. The accompanying table shows the figures for four different speeds. It may be seen from this table that the price of the motor decreases as the speed increases. However, the price of the pinions and chain increases as the speed increases largely because of the increase in size of sprocket to give the proper reduction ratio.

There is not much to choose from between the last three speeds (720, 900 and 1,200 r.p.m.) so far as price is concerned. However, in this case the 900 r.p.m. outfit was used in preference to the 720 r.p.m. outfit because it was easier to obtain this motor, and in preference to the 1,200 r.p.m. outfit on account of the decreased chain speed and the lower speed reduction ratio which would be obtained.

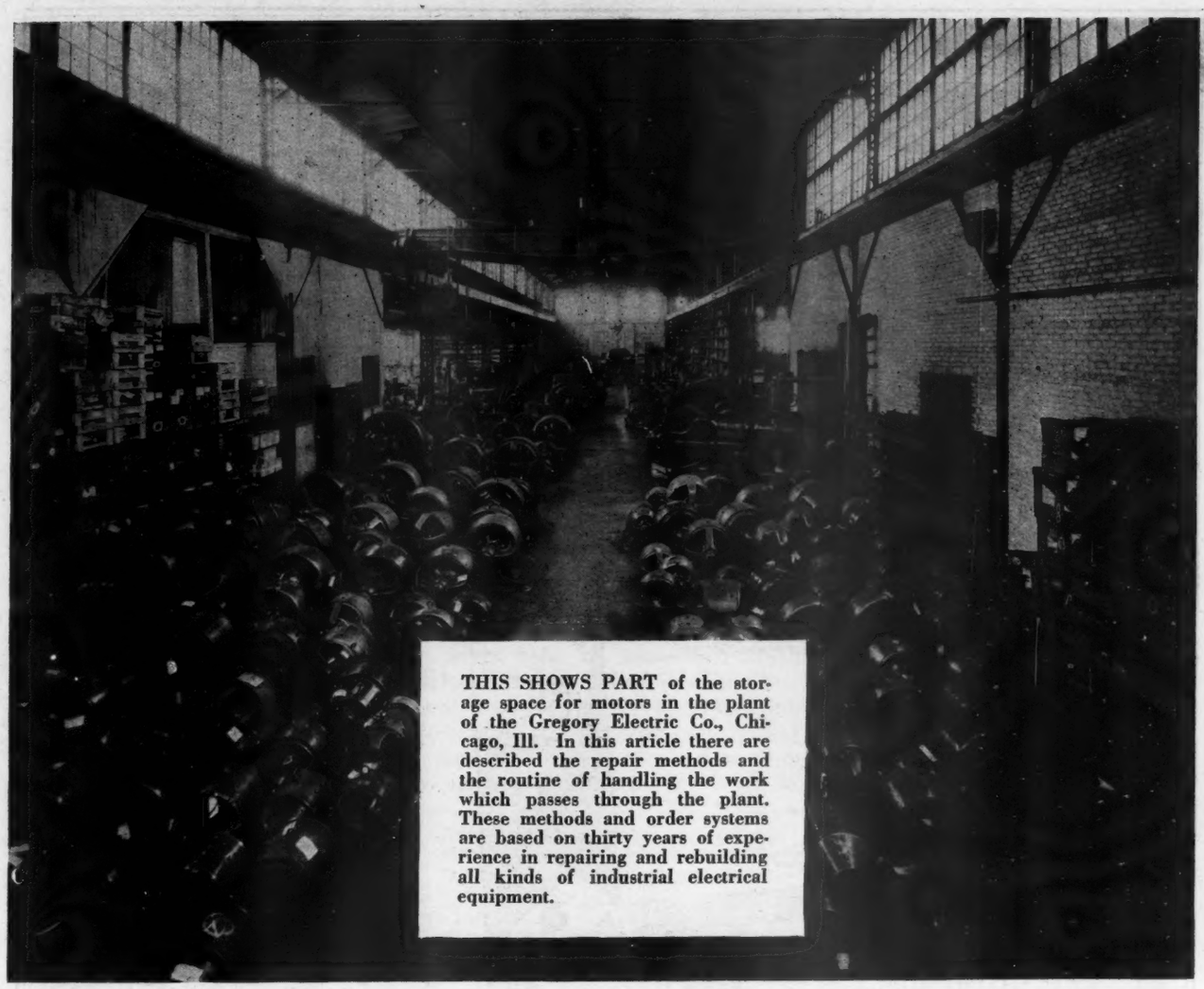


A 900 r.p.m. motor was found to be cheapest for this pump drive as shown by the table at the top of the page.

It is advantageous to inspect all roller chain and sprockets frequently. This need only take a few moments as it is not necessary to remove the chain. Look for broken or cracked rollers; inner side plates worn badly, which indicate poor alignment of sprockets or teeth too thick; links showing undue looseness, which indicate broken bushings or excessive pin wear; pins loose in the pin plates. Repair all defective parts immediately. Chains may run fairly well for a time with several rollers missing, but in the long run this is destructive both to sprockets and to the neighboring links. It is advisable to renew the entire roller link whenever a broken roller is discovered. Never attempt to take the roller link apart and merely put on a new roller. These roller links are assembled with great care and have just the correct amount of press fit between bushings and inside plates, as well as the correct dimensions over the side plates, and they can not readily be repaired without destroying these conditions. New roller links can be purchased cheaper than this repair can be made.

Where new industrial drives are contemplated or old drives are giving trouble or if for any other reason changes are considered in the transmission units it may pay to investigate the use of chains. They have been tried out in practically all industries and have many advantages as mentioned in this and the previous article. Another article will take up information required when ordering sprockets and a description of the problems incidental to a particular installation.

Editor's Note: Special acknowledgement is made to Earl C. Moss, Consulting Engineer, Chicago, Ill., and to the following companies for their kind assistance in furnishing information and photographs for this and the previous article on this subject: American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; The Jeffrey Manufacturing Co., Columbus, Ohio; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.



THIS SHOWS PART of the storage space for motors in the plant of the Gregory Electric Co., Chicago, Ill. In this article there are described the repair methods and the routine of handling the work which passes through the plant. These methods and order systems are based on thirty years of experience in repairing and rebuilding all kinds of industrial electrical equipment.

Details of Procedure in

Repairing and Rebuilding Electrical Equipment

In a Plant Which Has Specialized in This Kind of Work for Thirty Years

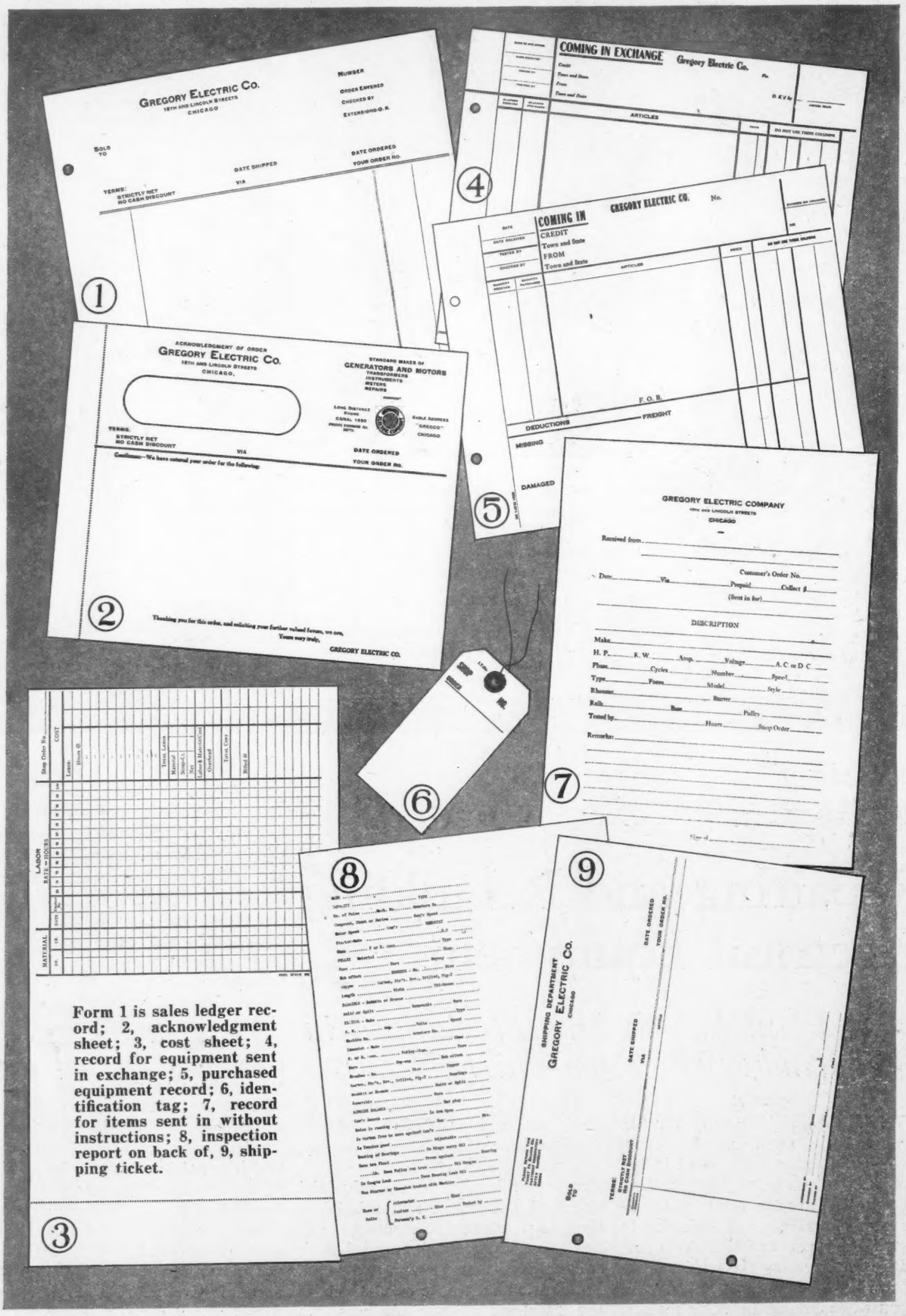
By J. D. ZOOK

Superintendent, Gregory Electric Company, Chicago, Ill.

REPAIR METHODS, routing of the work and the report and order forms used in the plant of the Gregory Electric Co., Chicago, Ill., are the result of thirty years of experience and endeavor to devise the best and simplest procedure for handling the wide variety of work which is done there. We buy used or damaged electric motors, control apparatus, transformers, meters and other kinds of industrial electrical equipment and rebuild it for resale. We make in our own shop most of the repair parts needed, such as bearings, commutators, and so on. In addition to this work, which is the backbone of our business, we rent out large numbers of motors and generators and do a good deal of commercial repairing of equipment. The fact that these activities involve the handling and repair of practically all makes, types and sizes of motors and other equipment renders it more difficult, and yet all the more necessary, to have simple but effective shop and office methods. The nature of our business makes it necessary for us to do our work thoroughly and with maximum efficiency.

All shipments of heavy equipment are received or sent out on a switch track which runs through one side of our plant. Pick-ups and deliveries around the city are made by motor trucks, in the case of equipment which is not too heavy to be handled in this manner. As soon as notice is received of an incoming shipment of motors or other equipment, the shop order clerk assigns an order number and makes out the tag shown in Group *A*, Fig. 6. The order number is a serial number and all charges are made against it. This

Group A, Office Records, Labor and Material Forms



Form 1 is sales ledger record; 2, acknowledgment sheet; 3, cost sheet; 4, record for equipment sent in exchange; 5, purchased equipment record; 6, identification tag; 7, record for items sent in without instructions; 8, inspection report on back of, 9, shipping ticket.

tag is sent to the shipping department and when the motor or whatever it may be comes in, the tag is attached to it and serves as an identification mark as the article goes through the various plant departments, including finished storage.

Motors and other equipment may be sent to us under any of the following conditions: (1) We have previously arranged to purchase the items. (2) They are for sale and have been submitted for examination. (3) They have been sent in for repair. (4) They have been sent in in exchange for other equipment.

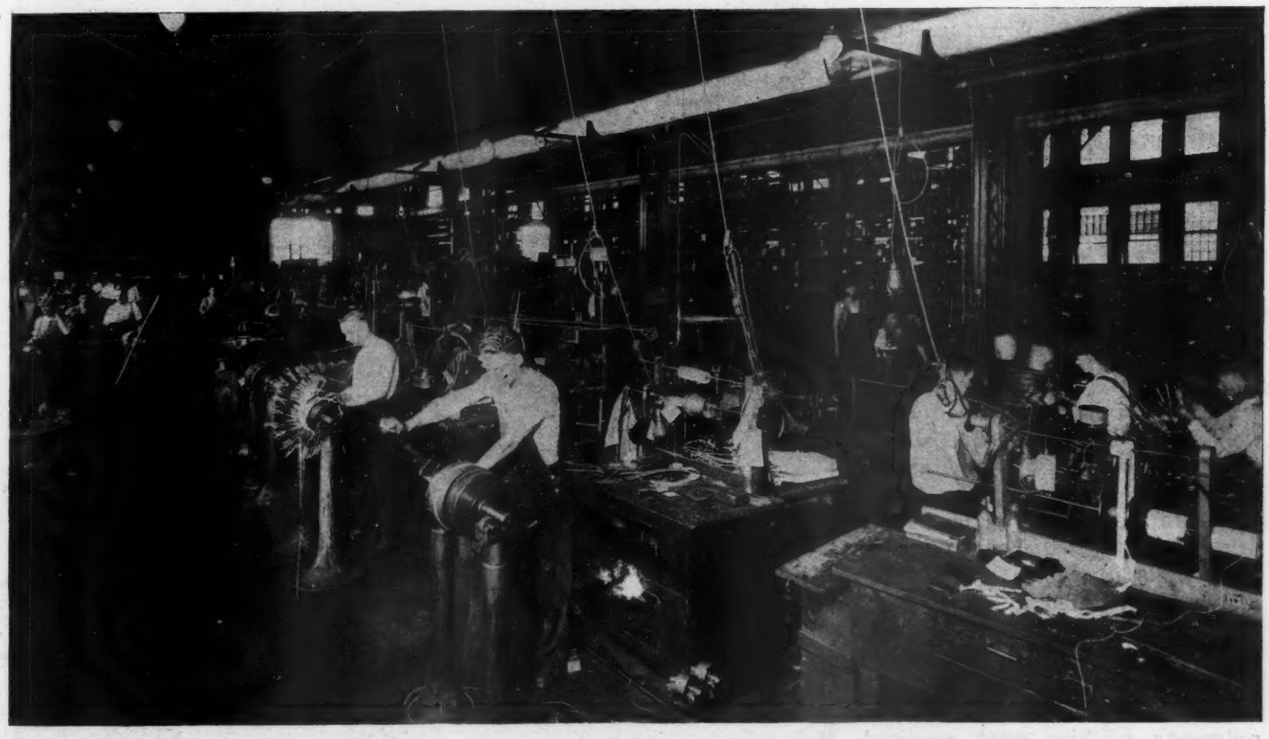
When equipment is sent in for repair, or if previous notification of shipment and advice as to whether it is to be repaired or is submitted for sale has not been made, one copy of the white form shown in Group *A*, Fig. 7, is made out and held until we can determine what the owner wishes to have done with the shipment. It frequently happens that motors and other apparatus are sent to us for one reason or another, but the owner either forgets to notify us that he has made such a shipment and state what his wishes are, or his letter goes astray. Without some record such as is given by this form a good deal of confusion and perhaps loss might result, as it may be several weeks before we know what to do with the shipment.

If the equipment in question has previously been purchased by us, a *Coming In* order is made out on the orange-colored form shown in Group *A*, Fig. 5. This orange sheet is sent to the shipping department and held until the material comes in. The receiving clerk checks the shipment for quantity or number of pieces and notes at the bottom of the sheet any parts which are missing, as well as any damage which has been done in transit. In the latter event, a damage claim is filed with the railroad company. The same procedure is followed in the case of equipment which is offered to us for sale. We make an examination and notify the owner what we are willing to pay for the equipment, which is then stored until he either accepts or rejects our offer.

If the equipment has been sent in in exchange for other equipment, a pink *Coming In Exchange* sheet Group *A*, Fig. 4, is made out instead of the orange sheet.

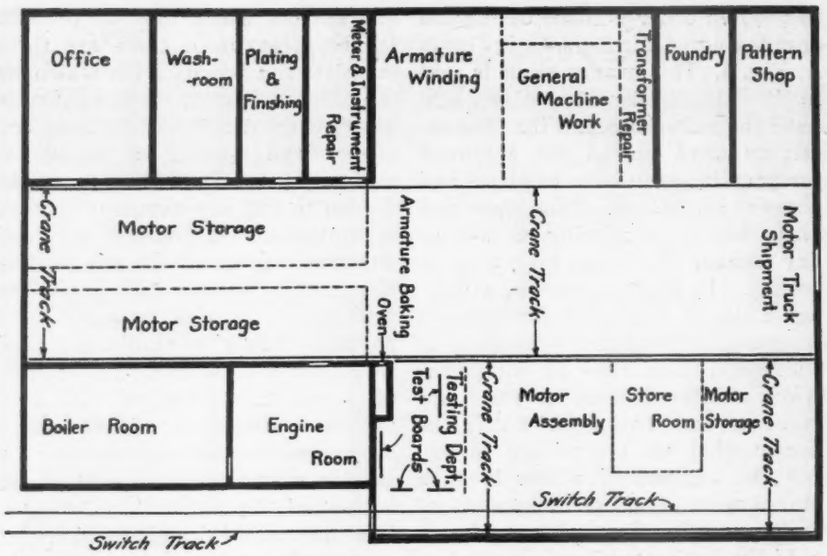
Every piece of equipment which comes into our plant is, then, first sent along with the orange shipping ticket, to the testing department where it is operated and tested to locate and determine the nature of any defects which may be present. In this department there are three main testing boards from which we can obtain any commercial voltage in direct current and any voltage, frequency and number of phases of alternating current, that may be needed to test any commercial piece of equipment. In addition to the instruments mounted on the switchboards the testing and inspection department is well equipped with portable types of indicating and recording instruments. In the case of a motor if any of the coils are burned out or grounded or other defects are found, the inspector makes note of them at the bottom of the sheet. The motor is then disassembled and the bearings, coils, commutator, shaft and so on are carefully examined. If a new commutator is required or the old one needs turning, or other repairs should be made, they are likewise noted. This sheet, which thus contains a complete record of the repairs needed on the motor, is then turned over to the superintendent for his approval.

If, in his opinion, the repair work specified on the sheet is needed and is justifiable in every way, he O. K.'s the sheet and the motor is sent to the department which is to do the work. In this way the superintendent is enabled to keep close watch on equipment which is purchased and also on all work which is done in the shop. We frequently



Armatures and small stators are rewound in this department.

The coil winding, spreading and taping machines can be seen at the right. At the extreme left a workman is testing out a rewound armature at the testing board. Each winder has his own bench fitted with drawers which can be locked and in which he keeps the tools used in his work. In the center background is a large rack in which is stored the stock of pulleys.



Floor plan of factory, showing location of different plant departments.

receive motors and other equipment which are not worth repairing. That is, the investment in labor and material necessary to put them in first-class condition would not be justified by the price for which we can sell an equally good machine. In such cases, we dismantle them and sell the material for junk, or if it is a repair job the customer is notified.

As is shown in one of the illustrations, which gives the layout of our plant, there are several separate departments each of which is devoted to a certain phase of the repair work.

The armature-winding department is provided with Armature Coil Equipment Company's coil-winding and spreading machines, Segur taping machines, a test board from which can be obtained any voltage from about 28 volts to 4,000 volts, and the other equipment which is necessary in order to handle properly a wide variety of armature and small stator winding. Coils for large stators are wound in the transformer repair section.

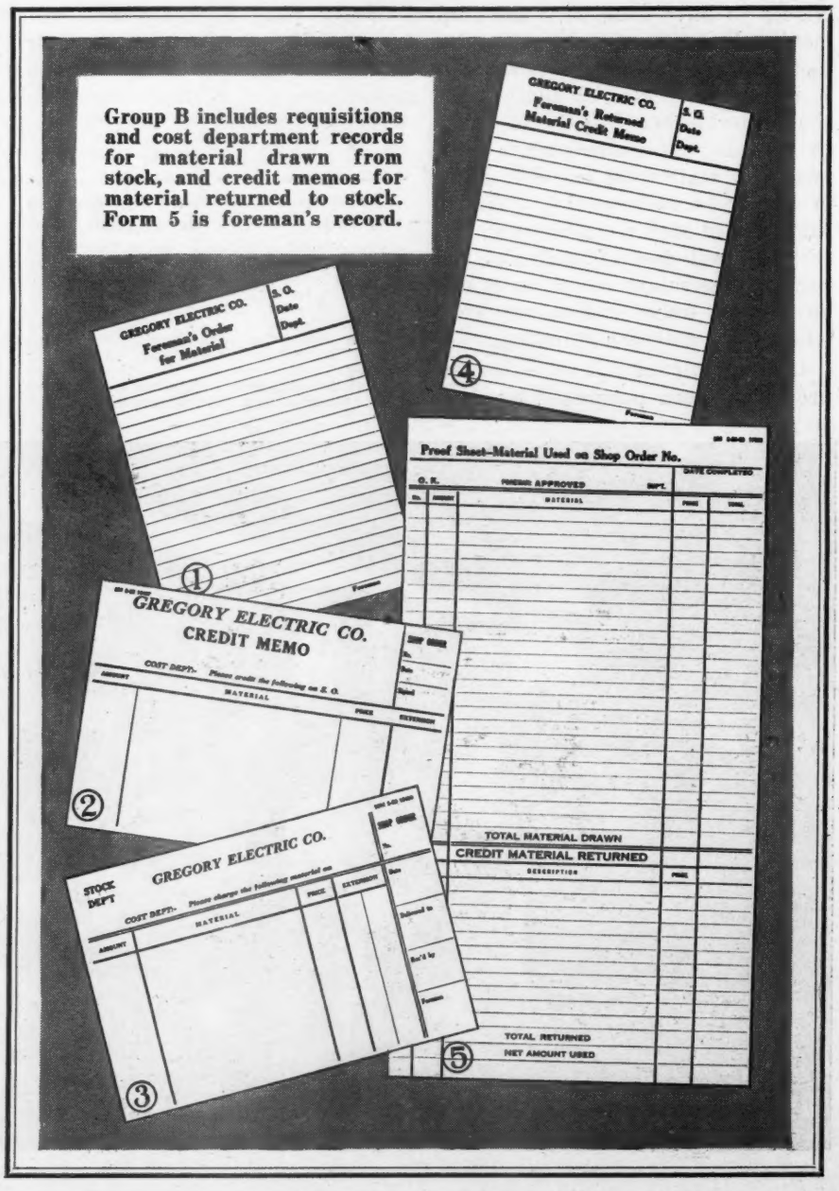
Another section is devoted to commutator work. Here commutators which need turning or other attention are put into good condition. If a motor needs a new commutator it is made in this department. The segments are cast in our own foundry, then put together and the commutator is turned to size finished and carefully tested.

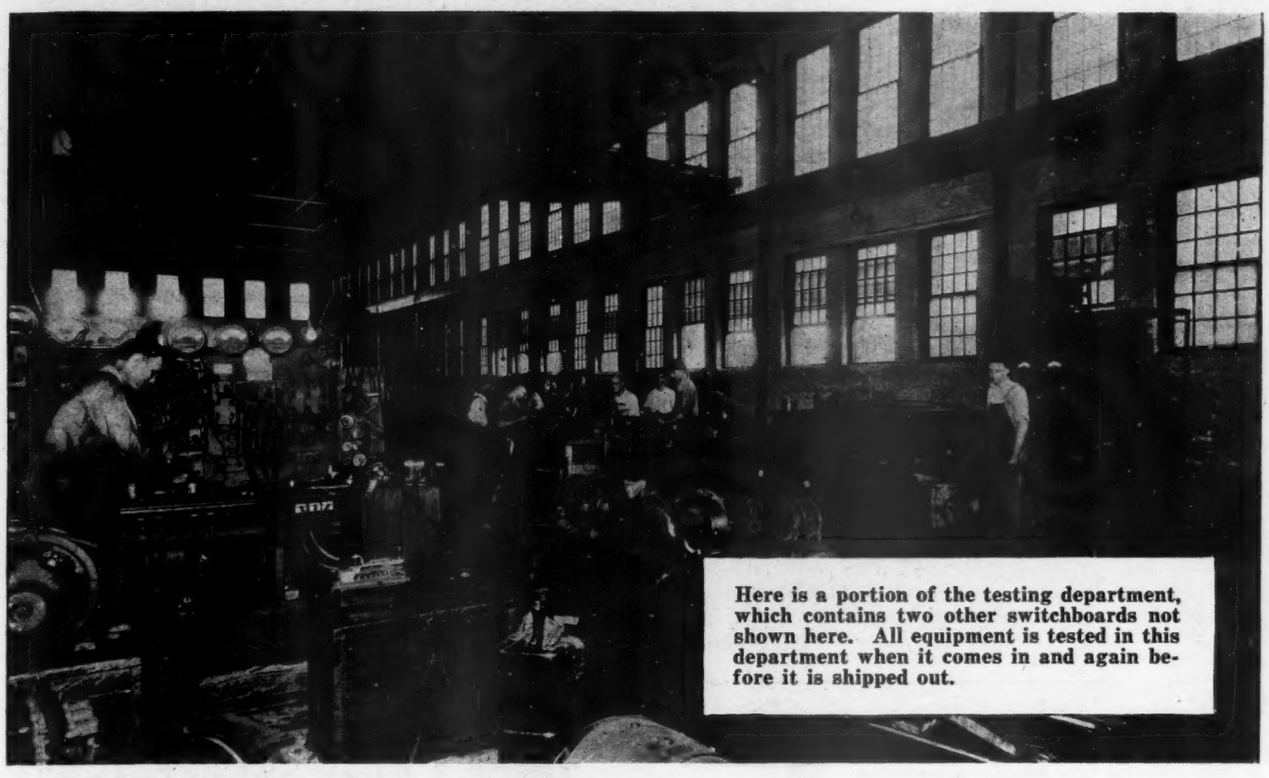
The machine shop, which is well equipped with lathes and other machine tools, all of which have individual motor drive, handles the miscellaneous machine work required, such as turning shafts, making new bearings and so on. We cast all of our own bearings in the foundry.

Patterns for commutator segments, bearings and other parts are made in another section which is devoted to this work.

In the transformer section, transformers and starting equipment are thoroughly overhauled, and defective coils or other parts replaced.

The meter department is equipped with the fine machine tools necessary for overhauling and rebuilding all kinds of electrical indicating and recording instruments. Testing and calibrating are an important part of the work of reconditioning meters and indicating instruments. In addition to the necessary, carefully-calibrated standard instruments there are available two motor-generator sets. From one of these any voltage from about 1 to 350 can be obtained: the other will furnish from 350 to 750 volts, so that combining the two we can get up to 1,100 volts, direct current. Transformers are used to



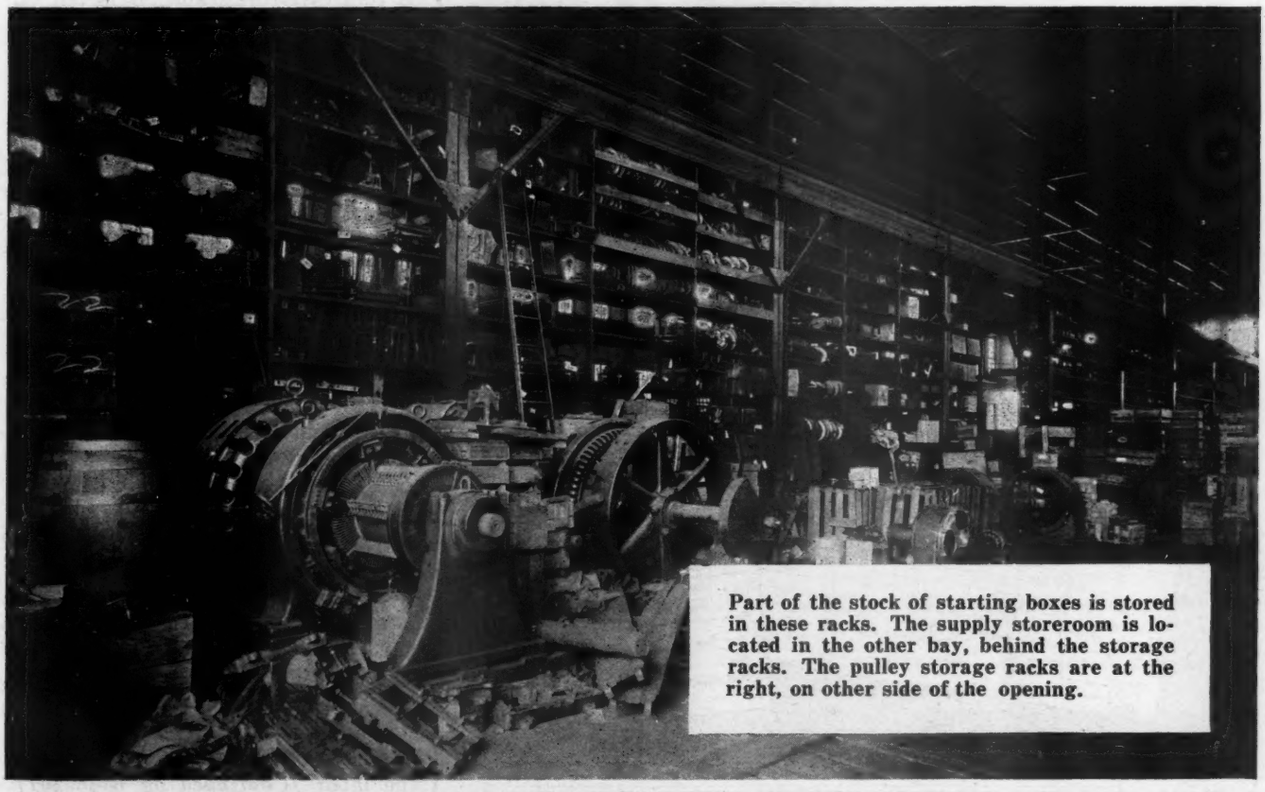


Here is a portion of the testing department, which contains two other switchboards not shown here. All equipment is tested in this department when it comes in and again before it is shipped out.

supply alternating current of any desired voltage. Besides these, we have a large plating generator from which we can obtain low-voltage current of any desired amperage. As an indication of the amount of work done in this department from 3,000 to 5,000 instruments are repaired or completely rebuilt each year.

As will be seen from the plant layout, the storeroom is centrally located so that it is convenient to all departments. Handling, as we do, anything from a fan motor to 200- or 300-kw. motors and generators, transformers, starting equipment and so on, makes it necessary to carry in stock a wide variety of replacement parts and supplies, in sufficient quantity to meet any probable demand. This stockroom is enclosed, all withdrawals must be made on properly approved requisitions and in general we feel that we have an efficient system of handling this department of the plant.

In order to operate and test the



Part of the stock of starting boxes is stored in these racks. The supply storeroom is located in the other bay, behind the storage racks. The pulley storage racks are at the right, on other side of the opening.

machines and equipment which is purchased or sent in for repairs, it is necessary to have available direct current at various voltages and single-phase, two-phase and three-phase alternating current of various frequencies and up to 10,000 volts. We find it advisable, therefore, to generate our own current. Our power plant contains the following units: One 100-kw., 220-volt, engine-driven, direct-current generator; one 75-kw., single-phase, engine-driven, 2,300-volt, alternating-current generator; one 20-kw., 250-volt, motor-driven, direct-current generator; one 50-kw., three-phase, 2,200-volt, motor-driven, alternating-current generator; one 220-550-volt, 10-hp., motor-driven, direct-current generator, and one 150-hp. engine, for driving generators under test.

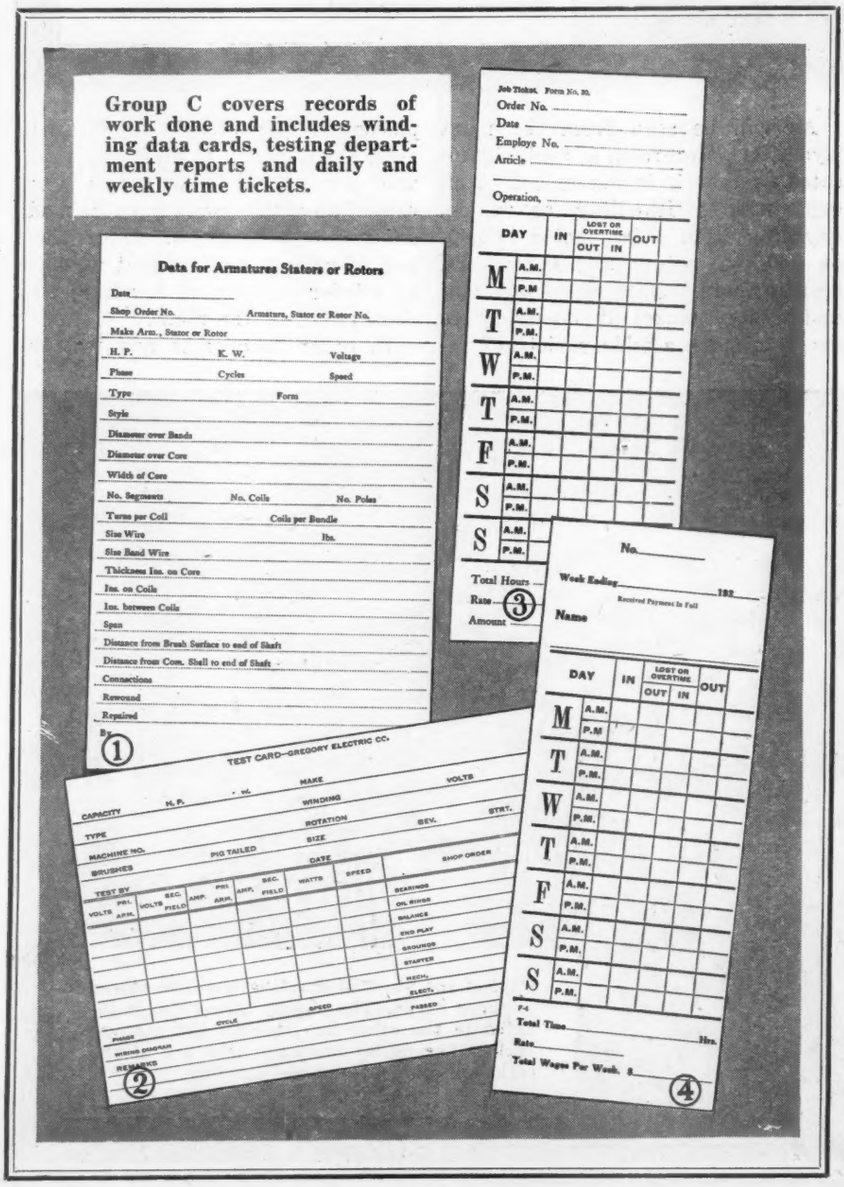
The system of routing orders received for sale, exchange, repair or renting out of equipment is the same in all cases. As soon as the order comes to the entry clerk he enters it, (1), on a white sheet, Group *A*, Fig. 1, in the case of a sale, or on a green sheet for a repair job. This white or green sheet, as the case may be, is filed as the original entry in our sales ledger, after shipment is made. As many duplicate white invoices are made as are required by our customers. (2) On a blank, tissue sheet for our correspondence files. (3) On a yellow, shipping department ticket, Group *A*, Fig. 9. (4) On the tan-colored cost sheet, Group *A*, Fig. 3, for a repair job, or on a pink sheet in case of a sale. (5) On a rose-colored acknowledgment sheet, Group *A*, Fig. 2. These forms are so arranged that they can all be made out, as carbon copies, at the same time.

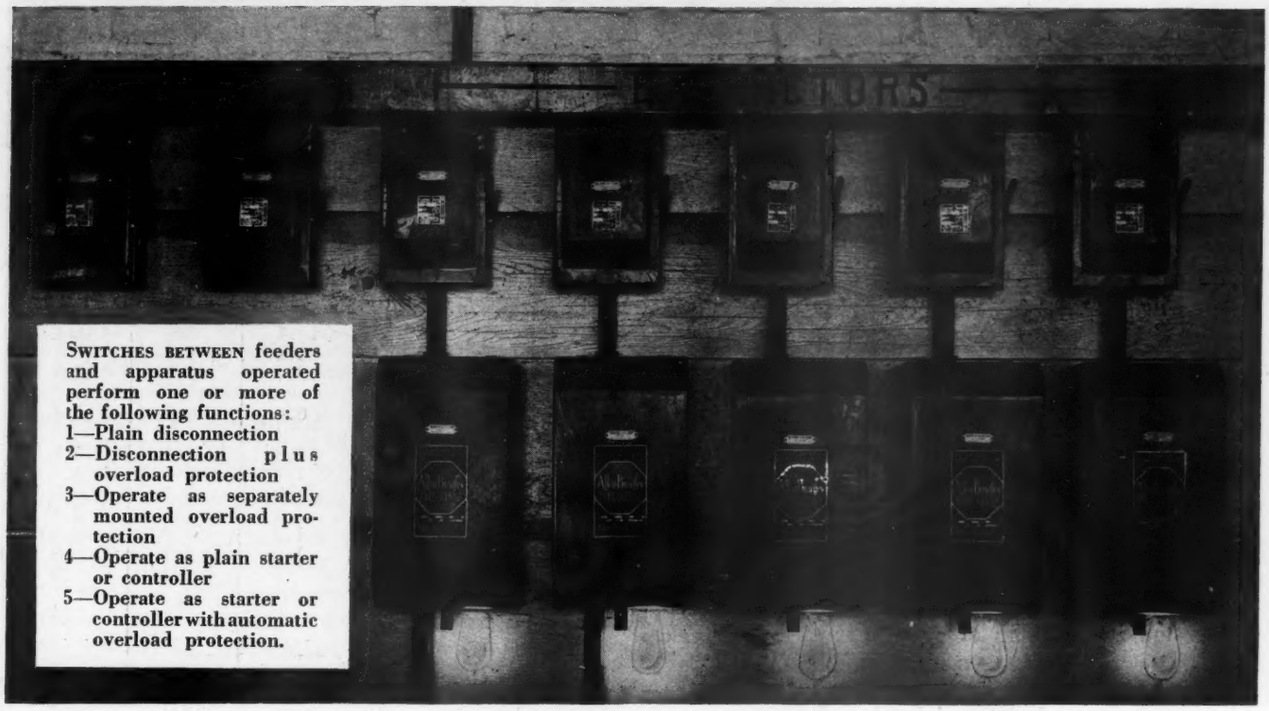
The routine which is followed when a machine or part is sent through one or more of the plant departments is as follows: As soon as we decide to repair for stock a motor or any other equipment which we have purchased, the cost clerk starts a white cost sheet Group *A*, Fig. 3. A separate sheet is filled out for each operation, such as rewinding armatures, fields or stators, refilling commutators and so on. As was stated previously, if we have already sold that motor the same entries are made on a pink cost sheet, of the same form as the one shown in Group *A*, Fig. 3, while a tan sheet is used for the repair jobs. The nature of the repairs needed has previously been noted by the inspection department on the orange *Coming In* sheet, Group *A*, Fig. 5. After the order is approved by the superintendent, the order and the part, armature in this case, are delivered to the foreman of the armature winding department.

When the job has been assigned to one of the winders, the first step is to fill out the data card shown in Group *C*, Fig 1. As will be seen, this card is one which can be used for armatures, rotors or stators and when properly filled out contains all the information which the repair man needs in order to rewind the part correctly. If a diagram of the connections or other information not provided for on the front of the card is considered desirable, it is put on the back of the card. These cards are carefully filed away and are very useful as reference sheets in checking up a winding in case any doubt or question comes up.

The wire, insulation, and other materials needed for the job is drawn from the stock room on the requisition form shown in Group *B*, Fig. 1. This requisition is signed by the foreman and turned over to the storekeeper. No duplicates or copies are made of this order which, after the material called for has been delivered, is filed by the storekeeper. The foreman has, however, as his record, a proof sheet, shown in Group *B*, Fig. 5, on the upper part of which he enters all materials ordered from stock. Each job has a separate sheet.

Each day, the storekeeper fills out and sends to the cost department, the form shown in Group *B*, Fig. 3. A separate sheet is used for each job on which material has been withdrawn. Each of these sheets is then pasted in the cost department to the labor *(Continued on page 401)*





SWITCHES BETWEEN feeders and apparatus operated perform one or more of the following functions:
1—Plain disconnection
2—Disconnection plus overload protection
3—Operate as separately mounted overload protection
4—Operate as plain starter or controller
5—Operate as starter or controller with automatic overload protection.

This is a sub-distribution and control installation used with push-button-controlled switches for extractor motors in the San Diego, (Calif.) Steam Laundry.

What Are the Requirements of

Protection That Safety Switches Can Provide

And the Construction Features That Are Essential to Insure That Protection?

By D. H. BRAYMER

Editorial Director, Industrial Engineer

IN INDUSTRIAL works during the past ten years considerable interest has been taken in Safety First movements that tend to prevent industrial accidents. This has been compelled in some instances by workmen's compensation laws and regulations of state industrial commissions and labor departments and by the insurance companies, but in the majority of cases this work has gained recognition because it has an economic reason as well as a humanitarian reason. Every workman has a just right to demand safe and sanitary working conditions. On the other hand, every manufacturing establishment profits in the long run by a reduction of preventable accidents through increased production and the elimination of wastes that accompany unexpected interruptions in processes of production. Continuity of machine operation at a maximum rate of production is an insurance against high production costs that is worth a definite expenditure in any works, large or small. And it is the job of the works superintendent and the heads of his departments to maintain adequate safety in plant operations as a part of their responsibility in connection with continuity of production at a maximum rate and a minimum cost.

In connection with any schedule of production, the continuity of power service to machines and processes of manufacture is just as definite a factor in cutting costs as the elimination of delays in the securing of a supply of raw material for machines to work on.

In this article the elements of protection that insure safety in the manipulation of enclosed externally operated switches at machines, their inspection, repair and maintenance and the resulting economies from the standpoint of the elimination of preventable accidents and interruptions of power service are discussed. The details revolve around the construction of so-called safety switches that are designed and used to cover four phases of protection which are as follows:

1—Protection for workers to prevent contact with live parts of an electric circuit.

Protection Essential with Enclosed Externally Operated Switches

1—Protection for workers to prevent contact with live parts of a circuit.

2—Protection for maintenance men working on electrical circuits or electrical apparatus and for men adjusting, repairing or working on machines liable to be started if current is accidentally turned on.

3—Protection to the electrical apparatus operated and to maintain continuity of service through prevention of electrical failures in circuits and machines.

4—Protection against fires and explosions caused from arcing of the switch.

2—Protection for maintenance men working on electric circuits or electrical apparatus and for men adjusting, repairing or working on machines liable to be started if current is accidentally turned on.

3—Protection to the electrical apparatus operated and to maintain continuity of service through elimination of preventable electrical failures in circuits and machines.

4—Protection against fire hazard from arcing.

The present use of the term "safety switch" is somewhat misleading unless qualified by the kind of protection that it provides under one or all of these headings.

Protection for maintenance men whose job it is to inspect and repair electrical circuits and equipment and who are usually designated as persons authorized to handle switches is equally, if not more, important than protection for workers at or about machines. By placing enclosed externally operated switches out of easy reach of workmen and locking the enclosing cabinet, together with proper installation and inspection by authorized maintenance men, a wide range of safety is provided.

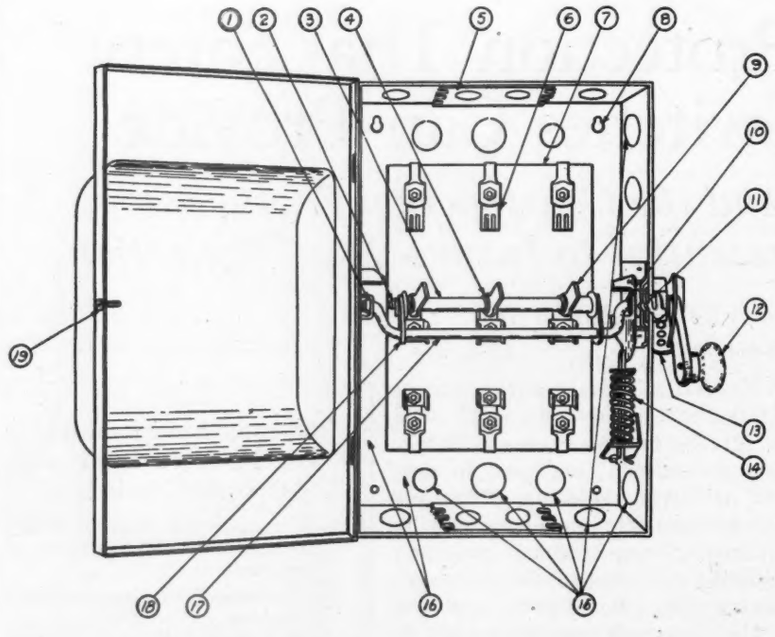
But in the case of protection for the authorized maintenance man, it is necessary to consider the conditions surrounding his work as similar to those of a fireman. His job calls for the location and correction of troubles and he is required to approach and handle circuits where hazards to life may lurk in unexpected places. A measure of protection is, therefore, essential against inexperience, carelessness, lack of observation, oversight, haste and the like in doing his work.

In large industrial works where the maintenance department is made up of experienced electrical men, the requirements of protection for these men are less rigid than in those plants where a part of the repair and maintenance work is done by the operators of the switch, so that the measure of protection that is essential in all cases should take into consideration the possible handling of switches by those not familiar with the hazards of live electric circuits.

Accidents and injuries can be traced to a variety of causes. The accompanying analysis of 1,214 minor accidents and 724 disability accidents, causing 6,867 days lost time, shows typical causes and the relative importance of each with the corresponding time lost during a period of seventeen months.

Analysis of Accidents and Time Lost In One Organization During a Period of 17 Months

Causes of Accidents	Minor Accidents Per Cent of Total	Disability Accidents Per Cent of Total	Days Lost Per Cent of Total
Poor judgment	29.2	31.8	30.9
Contributory negligence of others	12.8	11.5	14.4
Haste	6.6	10.1	8.9
Mechanical manner of doing work (Lack of concentration)	13.4	9.8	8.4
Method pursued not suitable for work	5.2	5.7	7.6
Rules or instructions not observed	3.4	6.1	6.0
Lack of proper inspection and maintenance (Defective tools, materials and devices)	6.4	6.5	5.4
Conditions beyond control (a) Elements (b) Non-Industrial	17.8	8.4	5.1
Lack of proper instruction	1.7	1.7	4.3
Physical condition of injured	1.2	3.7	2.8
Protective devices not provided	.5	1.1	2.4
Protective devices not used	1.2	1.7	2.4
Improper tool or device	1.2	1.2	.8
Willfulness	.1	.4	.4
Class of work beyond physical or mental ability of injured	.2	.4	.2
Intemperance	....	....	....
	100.0	100.0	100.00
Total number in 17 months	1214	724	6867



Construction details of the safety switch manufactured by Mutual Electric & Machine Company, Detroit, Mich.

These numbers refer to the drawing: 1. Drawn bearing. 2. Steel cross bar. 3. One piece horn fibre insulation. 4. Double insulation on cross bar "cold flowed" into the blade. 5. Removable end plate (interchangeable). 6. Break jaws and fuse jaws type "A" parts (not punched type). 7. Slate base. 8. Button hole for convenient mounting of cabinet. 9. Switch blade reversible; if damaged in service, turn it over. 10. Drop forged hub on which the interlocking mechanism operates. 11. Entire mechanism removable as a single unit, easily replaced. 12. Insulated knob handle. 13. Provisions for locking the switch in various positions, using one, two or three padlocks. 14. Quick-make and quick-break spring (switch will work with spring removed). 15. Standard knock-outs located in both sides, top, bottom and back of the box. 16. Ample wiring space along the sides and ends. 17. Steel operating lever. 18. Links which connect the operating lever to the cross bar. 19. Cover catch interlocking screw.

Main Elements of a Complete Electric Circuit in an Industrial Works

1—**Main bus of plant switchboard or substation.**
The circuit feeding this bus is provided with protection in the station design, from the standpoints of safety and continuity of service.

2—**Panel controlling the feeder leaving the main bus.**
This circuit is also a part of the plant design from an electrical viewpoint and usually carries full protection for safety and continuity of service.

3—**Feeder cable and wiring.**
This part of the circuit is insulated for the voltage it carries and designed for load handled.

4—**Disconnecting devices.**
These devices are installed to cut out the apparatus connected to the main feeder for inspection and repair and may be provided with or without overload and other protection.

5—**Protection for the apparatus operated.**
This includes overload, voltage and phase protection with the necessary starting and control mechanism.

6—**The apparatus that is operated from the circuit.**

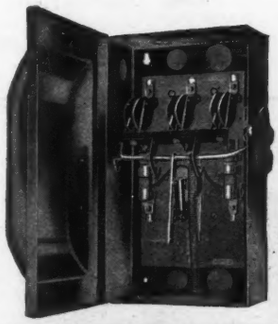
However, electrical hazards are by no means the largest causes of injuries to those who handle electrical circuits. One authority who has made a study of accidents reports that nine per cent of the total accidents reported were due to electrical shock, but in this connection the seriousness of this hazard is shown by an analysis which revealed that this nine per cent of all accidents was responsible for 72 per cent of the total cost of accidents, 75 per cent of the fatalities and 78 per cent of the lost time. Adequate protection of those whose job it is to work on electric circuits and who are authorized to do so is, therefore, imperative both from a humanitarian standpoint and from the standpoint of savings in dollars and cents.

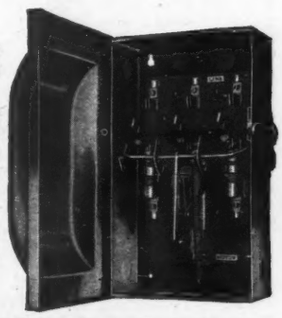
It is not proposed in this article to lay down a cure-all for accidents on electric circuits nor to attempt to show how one type of so-called safety switch provides such protection better than another. On the other hand it is proposed, first, to bring together the ideas of users of these devices to show the ways they are approaching the problem of protection through the use of switches that possess safety features and the requirements in operating and service conditions surrounding this work and, second, to show how the manufacturers of switches that possess safety features are trying to meet these requirements in their switches.

As a starting point it is important to get a correct picture of the main elements of a complete electric circuit in an industrial works and the parts of this circuit where protection through a switch that possesses safety features is essential from one or more of the four phases of protection mentioned above. These main elements of the electric circuit in every industrial plant of considerable size are given elsewhere.

The types of switches that are used between the feeder and the machine operated and provide protection from the four standpoints already outlined: namely, to the worker, to the maintenance man, to the machine and against fires, are sold under the names "safety switches" and "across-the-line-starters." From the standpoint of their use in industrial work a good but rough subdivision in the following groups was made by P. T. Vanderwaart, Electrical Engineer of the New Jersey Zinc Company in a recent paper presented before the Association of Iron and Steel Electrical Engineers. This subdivision into groups is based upon whether or not the switches perform one or more of the following functions:

A—Plain disconnection.
B—Disconnection plus overload protection. When considering a piece of apparatus which aims to combine the plain disconnect function with some other function, the device should not be so elaborate as to require a separate disconnect ahead of it.
C—Separately-mounted overload protection.
D—Plain starter or controller—including push-button-controlled "across-the-line" starters.
E—Starter and controller with automatic overload protection. These usually have overload protection in but two of three phases. They are recognized by the National Electrical Code as sufficient under competent supervision but do not protect against coincident grounds unless the unprotected wire is the grounded side of an

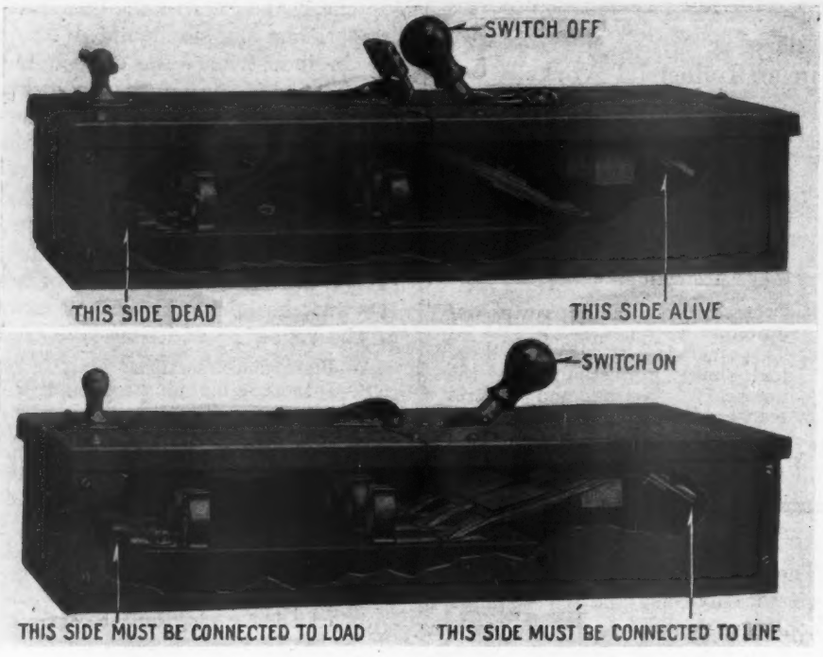




Motor starting switches with overload relay and under-voltage release coil to protect against single-phase operation. Made by Trumbull Electric Mfg. Company, Plainville, Conn.

Safety Switch Made by Square D Company, Detroit, Mich.

The illustration above shows porcelain cover protection for switch contacts. At the left is illustrated the construction which prevents opening the switch cover while the switch is in the on position except by means of a key carried by authorized persons.


SWITCH OFF
THIS SIDE DEAD
THIS SIDE ALIVE
SWITCH ON
THIS SIDE MUST BE CONNECTED TO LOAD
THIS SIDE MUST BE CONNECTED TO LINE

Enclosed auto-lock brush type of safety switch.

These switches are designed for industrial circuits of 250 volts a. c. or d. c. and 600 volts a. c. in ratings of 30 to 1,000 amp., with and without fuses. When the cover is opened it is impossible to touch live parts. When contacts are closed the cover cannot be opened. Made by The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

intentionally grounded circuit or otherwise made the same wire on all services.

Mr. Vanderwaart in his paper gave the following as essential points to consider in the operation and construction of the above groups of switches that possess protection features.

1—Are all live parts enclosed?
This protects the ordinary worker from coming into contact, but increases the hazard to the operator.

2—Is it externally operated?
This safeguards the operator.

3—Is it possible to so connect it that safety features are inoperative?
This is not objectionable if action is taken to prevent accidents due to violation of instructions, careless work and lack of education.

4—Suitable for location?
Is cast iron better than steel for the enclosing case?

5—Are all parts strong and compact without requiring excessive space?
Note desirability of having 200- to 600-amp. fused knife switches in 500-volt a. c. pole spacings instead of using the much wider 600-volt switch for 400-volt circuits.

6—Is it tamper-proof?
Comment on oil-immersed switch: If parts are out of sight under oil, it is a lot easier to resist the temptation to monkey with the adjustments to keep going under certain circuit troubles instead of running down the particular trouble.

7—Can unit or parts be quickly removed, replaced and repaired?

8—Ample wiring space?

9—Facility of arranging for conduit or open wiring connections?
Suggest stocking blank end plates which can be easily and quickly drilled in the field for most desirable conduit location or for porcelain bushings of any size. Eliminates expense of stocking several items and the requisitioning of particular ones suited for each job with the chance that the electrician finds some other type would better suit when he makes the installation.

10—Is provision made for easily connecting test instruments into the circuit?
Desirable where periodic motor load tests are made.

11—Is contact resistance liable to become excessive?

12—Can switch be locked in "off" position?
Necessary to protect electricians working on the circuit or appliance or men working on the driven apparatus.

13—Is it possible to open door with switch closed?
It should not be possible to do so if the operator is to be protected when replacing fuses. Same applies to items 14 and 15.

14—Is it possible to close switch with door open?

15—Is it possible to touch live terminals with door open?

16—Is it possible for authorized inspector, and he only, to inspect live parts without interrupting service?
This feature can be had and is sometimes desirable where it is important to keep the appliance energized continuously.

17—Is accidental closing of switch probable or possible?

18—Can disconnect be opened manually under extreme overload?
This sometimes has to be done and the success of the operation depends upon speed of break, barriers, etc.

19—Positive make on closing?
This means are you sure that the switch will be 100 per cent closed?

20—Quick make?
This is action similar to quick break, and is sometimes desirable.

21—Rupturing capacity.
When located close to large capacity sub-stations, this feature should always be checked up. It is here that some other type of overload protection than plain fuses must be considered.

22—Characteristics of overload device?
Effect of zero weather. Adjustable settings for time limit and minimum current to trip. Time-current characteristic. (Remember the cumulative effect of "creeping." That is, if the relay has started due to the action of a high current and the current decreases to a lower value, the remaining time to trip may be very much less than if the relay had started initially under the lower value of current.) Permissible deviation. Non-automatic reset with U. V. release. Comment: Volt, amp., watts, temp. rise. (Well to have.)

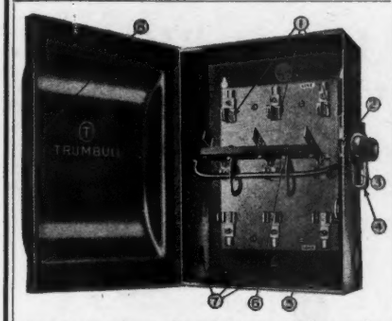
23—Is operation of double-throw motor starter positive?

24—Does switch provide undervoltage protection, and can it be arranged for undervoltage release if desired?

25—Characteristics of operating coil in electrically operated starters?
Volt., amp., watts, temp. rise., (Desirable to have this information.)

Externally operated fused switch designed for industrial circuits and as a meter service switch.

The construction is shown at the right. The switch and box are standard with or without meter. made by the Palmer Electric & Manufacturing Company, Cambridge Mass.



Construction of safety switch made by the Trumbull Electric Mfg. Company, Plainville, Conn.

1. Built-up contact jaws. 2. Safety catch. 3. Hinge rivet is upset and can not loosen. 4. Can be locked open. 5. Ample room for running wires. 6. Quick break. 7. Knock-out—ends, sides and rear. 8. Pin with which catch operates.

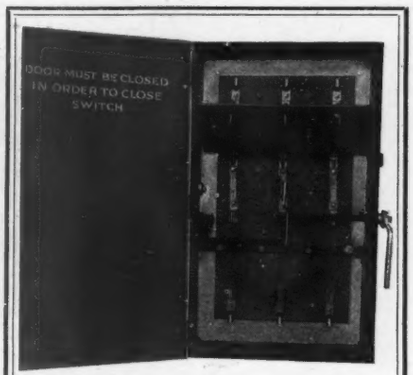
In view of the fact that the Association of Iron and Steel Electrical Engineers has devoted considerable attention to the use of so-called safety switches and that the Pennsylvania State Department of Labor and Industry has required certain protective features on such switches since July 1, 1917, abstracts are presented in what follows of comments by members of that association in its discussion on the subject. These comments reflect experiences with switch protection and the requirements of service in connection with different mill operations and processes.

The service conditions in the state of Pennsylvania are similar to those of other states and are well summarized in the following comment before the Association of Iron and Steel Electrical Engineers by Morton G. Lloyd, Electrical Engineer and Chief of Safety Section, Bureau of Standards, Washington, D. C.:

I think the statement made by one of the speakers could be accepted by all of us: that the manufacturer can give us what is required to do the work if we know what we want and are willing to pay the price. To me, the principal question in connection with this subject is to determine just what we do want; what is really needed as to the type of enclosed switch under the different circumstances where one is to be used. We have available now almost everything from the mere enclosure for the switch up through the range that was described in the paper this evening to a type that is substantially fool proof—that is, one where it is almost impossible under any circumstances to come in contact with a live part and which it isn't easy to wrongly connect.

Under given circumstances of use, which one of the various types should be selected? Assuming that you use an enclosed switch for the protection of persons from accident, the question is then, how far is it worth while to go in trying to protect those who may use the switch from accident, that is to say, from shock or contact with live parts?

The mere enclosure of the switch, as was said in the paper, is sufficient to protect anyone except the user of the switch. In most installations we have combined with the switch the element of protection to the circuit from overload — that is, either a circuit-breaker will be used or a switch will be installed with fuses. If fuses are to be renewed when they blow by the man who is working on the job, it is usually considered desirable that those fuses should be killed before they are handled. To accomplish that purpose



Enclosed externally operated switch with box made in two parts.

This construction makes it easy to remove the sides and ends and facilitates wiring. Made by the Wayman Electric & Manufacturing Company, East Palestine, Ohio.

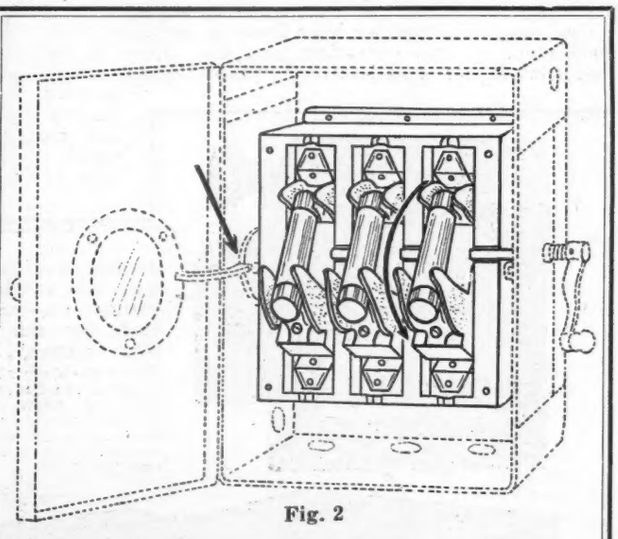


Fig. 2

Dead-front switch with all conducting parts including fuses encased in insulation.

The fuses are automatically thrown into and out of circuit with the throw-off handle. Fig. 1 shows switch on and cover open with no exposed live parts. Fig. 2 shows switch in process of being turned to off position. Fig. 3 shows switch in off position with fuses in position for changing. Switch cannot be operated when the door is open but door may be opened safely when switch is either off or on. Made by the Super-Safety Electric Switch Company, Chicago, Ill.

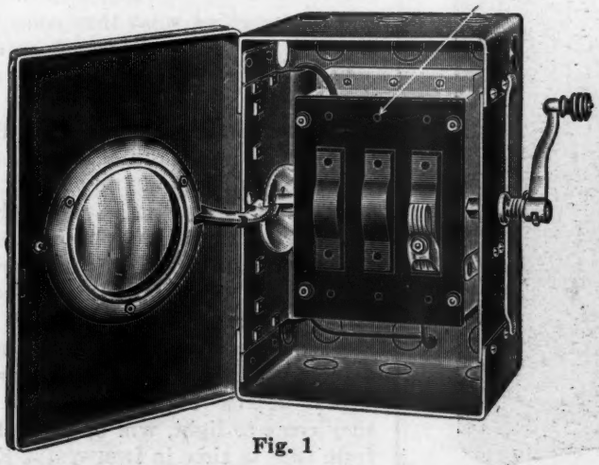


Fig. 1

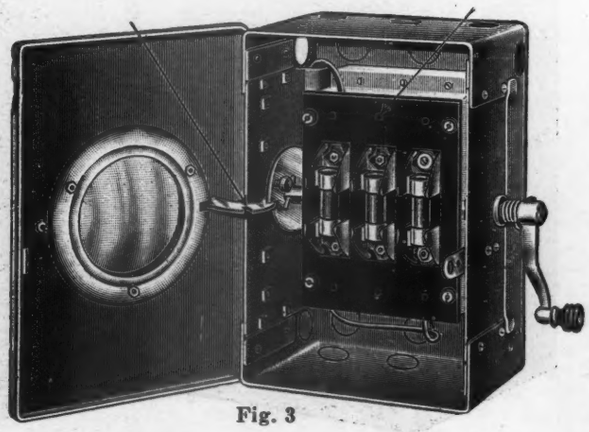
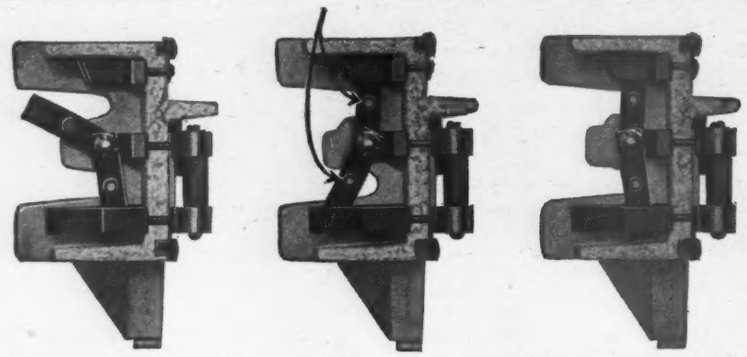
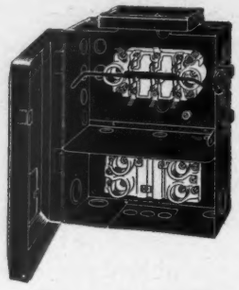


Fig. 3



Cross-section through porcelain switchblock showing off (at left), start and run positions of switch.

This construction is used in switches made by the Union Electric Mfg. Company, Milwaukee.

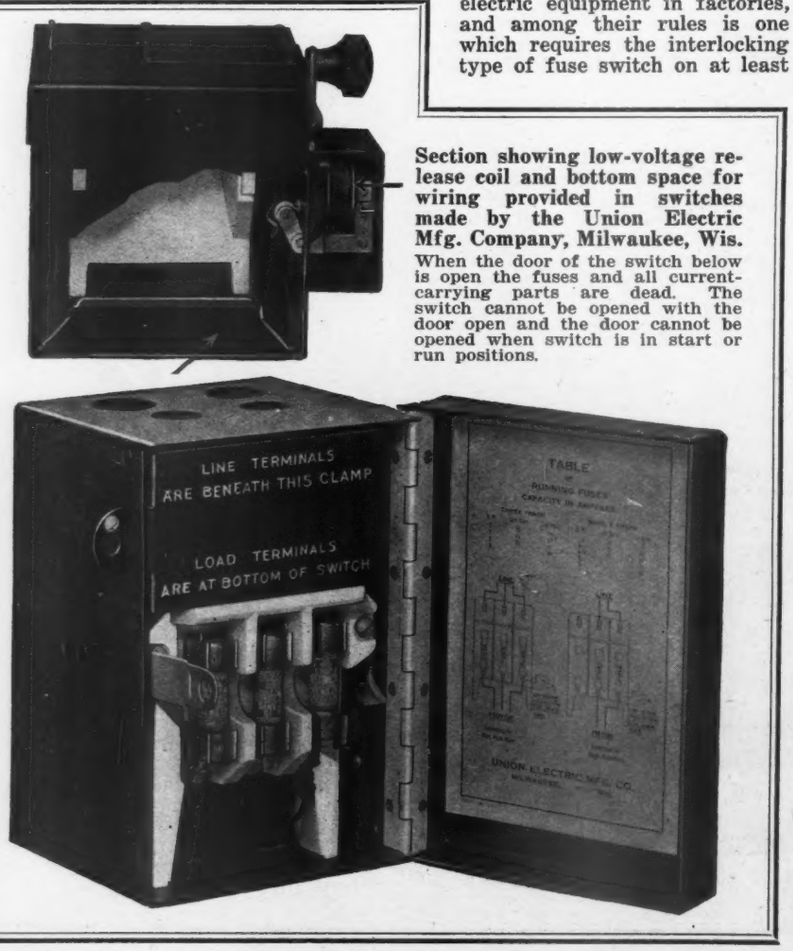


Safety switch made by the Aurora Steel Products Company, Aurora, Illinois.

one of the types of safety switches that we have on the market is a type with an interlock between the switch handle and the cover of the enclosure, so that the fuse is not accessible until the switch has been opened. That then renders the fuses dead before they are actually taken out for renewal, and that protects from shock a person who has to renew the fuses. However, in a good many types of switches that also renders it impossible to see the switch or inspect it in actual service, because to open the case to see it you have to first open the switch.

One complaint that we hear from a good many of you operating men is that that is not a satisfactory condition; that you want to be able to inspect the switch with the circuit closed; and to meet that we find that a number of manufacturers have brought out types that will accomplish that. One method of doing so is to have two compartments—one for the switch and one for the fuse and to interlock the fuse compartment, and to put a permanent lock on the switch compartment, so that it is only accessible to the man who has a key to that lock. He will usually be the plant electrician who is supposed to know enough about his work to safely open the switch compartment with the switch closed.

Here in Pennsylvania, your State Department of Labor and Industry has adopted some rules covering electric equipment in factories, and among their rules is one which requires the interlocking type of fuse switch on at least circuits of higher voltage, such as a 440-volt motor circuit. It is a question whether that much protection is really needed. It is another equally important question whether that same protection should be required on 110-volt circuits; the answer to this question so far has been very largely a matter of opinion. I do not think we really have enough data as to actual experience to finally determine the answer to either one of these questions and those who are interested in this subject and are concerned with the making of rules that must be followed by industrial plants are very anxious to get the information and the data from experience that will give a final answer to these questions.



Section showing low-voltage release coil and bottom space for wiring provided in switches made by the Union Electric Mfg. Company, Milwaukee, Wis. When the door of the switch below is open the fuses and all current-carrying parts are dead. The switch cannot be opened with the door open and the door cannot be opened when switch is in start or run positions.

In the January, 1923, issue of INDUSTRIAL ENGINEER the following request for information from a reader was published:

> WHAT MAKES A SAFETY SWITCH SAFE?—When installing safety switches the user has in mind protection from fire and safety hazards. I would like to see published in INDUSTRIAL ENGINEER comments from both users and manufacturers of safety switches on what they consider the essential points in the construction and use of the enclosed type safety switch.
> Detroit, Mich. J. H. R.

The letters that have been received from readers in answer to the questions outlined are presented on pages 395 to 398. In the meantime, letters were addressed to the manufacturers of safety switches requesting that they outline what they consider *the ten essential points of safety switch construction* to meet the requirements of protection needed in industrial electrical circuits. The answers from manufacturers are presented on pages 398 to 401.

These comments show that manufacturers are studying the protection requirements of industrial service and that standards of construction are being established as the requirements of users and their service conditions are made known. Other details of developments as they come to light, will be presented from time to time in INDUSTRIAL ENGINEER.

What the User Expects of a Safety Switch

From the standpoint of its protection for workers, maintenance men, machines and against fires and its ability to handle service requirements in operation

P. T. Vanderwaart, Electrical Engineer, The New Jersey Zinc Company, Palmerton, Pa.: In what follows I am mentioning some of the most important factors which should be considered in safety switch construction.

1—Heavy welded sheet steel or cast iron enclosing case having a well-fitted door with provision for external operation of switch and with provision for locking the switch in the open position.

2—High mechanical and electrical factors of safety.

3—Provision for subconscious inspection that fuses are positively disconnected before replacing them. This is probably best accomplished by having the open switch blades visible to the operator when replacing fuses.

4—Provision for inspection under load by an authorized inspector and he only.

5—Interlock to prevent opening the fuse enclosure when the switch is closed and to prevent closing the switch when the fuse enclosure is opened.

6—Dust proof and sufficiently moisture proof to prevent rusting of parts which are not ordinarily protected by paint. This will require the use of brass bolts and nuts for switch parts.

7—Provision for quick repair of switch parts without demounting the enclosing case or disconnecting conduits.

8—Positive make and quick break with necessary accessories to give the switch a rupturing capacity of at least ten times rating for 30-amp. and 60-amp. switches decreasing to at least two times rating for 800-amp. switches. Switches to be marked with the current which they can safely interrupt.

9—Assurance of sufficient contact surface and pressure to prevent heating after a reasonable amount of operation and burning of the switch blades and clips.

10—The designs should be such that all the good results of "quantity production" can be realized, enabling the switch to be put on the market at a price which the customer can afford to pay. A price of from 15 cents to 25 cents per ampere of rating respectively for large and small switches should bring in the business.

G. H. McKelway, Westfield, N. J.: Of the two kinds of danger which it is attempted to avoid by the use of safety switches, the danger from fire is much less important than the danger of injury to persons operating or maintaining the switch.

The arc drawn when operating the ordinary type of knife switch on all ordinary loads is very small and seldom amounts to very much even on heavy overloads, which would be expected to open the circuit breaker or blow the fuses protecting the circuit. Therefore, unless the switch has been placed very close to inflammable material or where there are gases that might be ignited when the switch is opened, the danger from fire should be almost negligible. The enclosing of the fuses in the same covering that protects the switch may add slightly to the safety from fire but, if cartridge fuses are used there is but little danger of the fibre casing surrounding the fusible element being destroyed except on a dead short circuit with plenty of station capacity behind it.

So far as protection to persons is concerned, there should be no opportunity for anyone, at any time, being able to come into contact with any live parts. The fuses should be installed on that side of the switch where they will be dead when the switch is open and the construction of the enclosing box should be such that the compartment in which the fuses are installed cannot be opened while the switch is closed. The blades should also be dead when the switch is open so that any repairs to them can be made with safety and while working upon them it should be impossible for the repairman to make contact with the jaws, which should be the only parts alive at all times.

There should be provided a means of locking the switch in the open position so that it can not be closed by mistake while anyone is working on the circuit controlled by it or on any machines operated by motors receiving their current through that circuit.

Ralph H. Hoyt, Detroit, Mich.: The present tendency in making a switch installation is to make it not only safe from fire hazard, safe from persons tampering with the installation, other than those authorized to do so, but also to make it safe for the persons who operate it. For these reasons the manufacturers have developed lines of safety switches to meet this demand which can be classified as follows:

1—Switches operated externally with no safety feature other than the inclosure.

2—Switches operated externally but only accessible with the switch in the open position and to those who are in charge.

3—Fused switches, the fuse compartment being so interlocked with the switch that the fuses are accessible only with the switch in the open position.

In making an installation it is necessary to choose the right type of switch for its purpose, without incurring unnecessary expense, and still secure the safety features of the switch. The first class of switches might be considered as a disconnecting switch, where the duty is not heavy, where a maximum of over 110 volts per pole is not exceeded, and only accessible to authorized persons. Class number two should be used as a disconnecting switch where there is a heavy load, where there is over a difference of potential of 220 volts per pole and for fused disconnecting switches where a maximum of over 250 volts per pole is exceeded and not over 150 volts to ground. Class number three should be applied to all ungrounded alternating current systems, as a switch feeding from a high tension line and also used ahead of other control apparatus.

With the advent of the safety type of switch, it was at first thought that all that was required was to place a switch in a box and enclose it, without much thought as to how this would affect the operation or life of the switch. This inclosure led to many difficulties, such as the operator in throwing the switch could not tell whether it was way in or way out as the case might be. Due to excess arcing because of this, the contacts soon became pitted and the switch had to be discarded; by reason of the fact that little thought was given to the size of box necessary to dissipate the heat when the switch was pulled under load, it became badly burned and from frequent operation soon gave out. Because of frequent renewals from the above causes it not only made a costly installation, but also a hazardous one as well, as it was often necessary to make a replacement when the line was hot, or else close down the line which it controlled.

Due to the failure of these switches, cost of maintenance and frequent renewals, questions arose as to the advisability of installing them. The manufacturer, because of the complaints entered, soon began to make a scientific study of the requirements necessary, which has resulted in the present lines of safety switches, which have positive operation, simplicity of parts, and ruggedness of construction.

For satisfactory results a large amount of space is necessary especially near the points where the current is interrupted, so that the arc will not be confined but have plenty of room to become dissipated. In general the distance to ground should be equal to the distance between poles. On switches of 500 volts or over and in case of fused

switches, barriers are provided between poles. On medium and large capacity switches special arc-quenching barriers are provided.

Because of the fact that switches became burned, caused by the speed with which they were operated, a spring or toggle arrangement was resorted to whereby the switch has a quick make and a quick break. With the development of the first of these switches many faults arose. It was found that due to the impact of the quick make and break arrangement the parts would soon become loose and fall apart. To overcome this, much heavier parts were used with special riveting and fastening, with a much more rugged switch as the result.

The safety switch has many applications, one of which is motor starting. In this field the switch meets its real test. The design has to be such as to take care of the initial rush as well as the normal current so that there will not be excess heating or burning of the contacts. With the older types of switches used in this connection, it was quite common practice to supply oversized fuses to take care of the initial rush of current. This created a very undesirable feature in that the line was not properly fused. Now there are on the market time element devices or thermal fuses which take care of the momentary peak loads, and still have the correct size of fuse.

The location of a switch has an important part in the construction of it. A switch mounted in a damp place, or a place that is subject to sudden changes of temperature, needs special attention as to sealing, otherwise the switch becomes corroded and may fail without any apparent reason.

It is to be remembered that no matter what the construction of the safety switch may be, if an incorrect application is made, the safety features of the switch may be entirely destroyed.

***H. Hollis, Superintendent, Electrical Department, Bethlehem Steel Company, Lebanon, Pa.:** I have always been of the opinion that the development of the safety switch was brought about more with the idea of protecting the man who has to operate the switch rather than the electricians who are supposed to be more or less trained men on the job and can reasonably be expected to take the necessary precautions to protect themselves. I sometimes think that, as the development of the safety switch has only extended back a matter of four or five years, that we sometimes expect too much from a new piece of apparatus. Some of you will remember the early development of the oil switch —one point brought out by a speaker was that a man was shocked by one of the blades of the safety switch that was supposed to be open remaining in. I had an experience personally with a 2,200-volt oil switch, which was composed of two double pole elements, operated by a common lever. This switch was on a 150-hp. motor. The fuses blew and I attempted to renew them. I saw the switch handle was open and had renewed one fuse, but when I put the remaining fuse in I had a 2,200-volt short circuit. From that experience I think we ought to give the manufacturer a little more time to make a perfect product. It is something that has to be worked out as we have to use them, the Pennsylvania State Electric Code adopted in July, 1917, making this compulsory. I think it is up to us to be a little more patient with the manufacturers and co-operate as much as possible with them in giving them suggestions due to our experience with failure of operation, to help make the safety switch a perfect product.

***J. R. Bower, Assistant Master Mechanic, American Car & Foundry Company, Berwick, Pa.:** We have not had any serious trouble with the safety switches, either due to accident to the men, break-downs or burning of the switches, although I find that these are frequent complaints from various plant engineers. I believe that our success along this line is due to two reasons—first, I believe that we are using one of the best safety switches on the market today; second, we do not exceed 250 volts in our plant. I believe that a great many of the men who are making complaints due to flash-over and burn-outs are using from 440 to 550 volts. However, with the little trouble we are having with the safety switch, I am not satisfied with the greater majority of them due to the fact that they have fuse protection. If we go back a few years we will recall the time when we used an open lead wire for a fuse on an open switch. A little later the enclosed cartridge fuse was introduced, and still a little later came the re-fillable fuses, which at the present time are made by numerous manufacturers, and there are several good ones on the market today. The trouble we are now encountering is the constant blowing-out of fuses, over-loading of same, refills, new fuses, fuses getting lost or burning to such a point that they are not usable, which is making an exceptional high maintenance cost to which there seems to be no end. Now that there are safety switches on the market, using circuit breakers and magnetic relays or contactors, that are worked out to such a high degree of engineering, and the cost coming to a point where they are not prohibitive, I believe that the day of the fuse is passing, to be replaced by these enclosed circuit breakers and magnetic relays or contactors.

***A. J. Standing, Superintendent Electrical Department, Bethlehem Steel Company, Saucon Plant, Bethlehem, Pa.:** Granting first the premise that we are interested in the safety of our employees primarily from a humanitarian standpoint, and, secondly, from the standpoint of compensation cost, the fact then comes up that the Safety Welfare statistics show I think that about 80 per cent of the accidents in industry are attributed to carelessness and ignorance, and the remaining 20 per cent are therefore attributable to lack of safeguards and safety protection. The other question that comes up, is protection for a skilled man, and protection for a non-skilled man.

In other words, where are we going to draw the line of demarcation between switches which should be converted to safety switches and switches which are normally safe as knife switches? By that I mean, take your power house station, your control pulpits, in locations which are accessible primarily to the men of your electric department whom we assume in that respect at least are trained men as compared to the average run of plant labor. Assuming, therefore, that the switches that we are most interested in are those switches in and about your general plant with which the unskilled and common labor comes in contact, that as a starting point simplifies our problem and gives us a cheaper point from which to start. It also means this: that you see today switches running up to 100 amp., 200 amp., of the type used in steel mills, that is practically where we start. If we take our standard steel mill construction as applied to an average table motor of 75 to 100 hp., you are going to have a tremendous number of very high priced switches which, in turn, will take up a large space.

I think, therefore, the point of attack on this subject is first, to take care of those isolated lighting switches, and units of that kind, which are scattered broadcast over your plant, can be readily mounted from a cost standpoint and will accomplish the greatest good from a safety standpoint, taking into consideration your untrained men. We consider the safety switch as a unit as we see it today. Our requirements are somewhat contradictory. We want a switch which has adequate spacing to handle the voltage and current demanded of it, and yet, at the same time we want that switch small enough to be readily mountable in places which we have provided to mount switches in. In other words, you can not have a switch of such size that it is going to be interfered with by passing objects—ingots and boxes and stuff like that; another thing is, we want the switch rigid and strong and unbreakable, because the switches are operated by sticks and poles by anybody going by in a car; and at the same time we want the switch reasonably cheap.

These four extremes in the manufacture constitute rather a hard problem. The manufacturer has got to lead us somewhere in that region with a switch which will do our work as far as current and voltage

*These comments were presented at a recent meeting of the Association of Iron & Steel Electrical Engineers during a discussion of safety switches.

is concerned, and yet will not place an undue cost on our product. There is no question in my mind but what the trend is coming toward safety switches, but the more or less sudden upstart of the safety idea which has resulted under the severe Compensation Laws, has brought about a complexity of switches, and it is questionable whether some of them have involved very many safety features. Now, today, in analyzing these switches as we see them, there unquestionably has been a marked improvement, but it is a question whether there isn't a great deal of room for improvement. I think one speaker mentioned the quality and strength of the enclosing boxes. Practically every box today seems to be rather light. Another point is from the standpoint of the electrician working inside those boxes. If he has any live connections to make he is in danger of grounding his pliers and getting a burn himself. Another point is that when the switch is enclosed it has to be dust proof and moisture proof; at the same time you have got to ventilate your switch box so you do not have dangerous gas collections and explosions. These are just a few points, but it means that we have got to start at the thing from a safe and sane standpoint and not rush into it simply to save ourselves a little compensation cost.

***H. S. Boone, Plant Engineer, Shoemaker-Satterthwaite Bridge Company, Pottstown, Pa.:** A great deal seems to have been said about the enclosing of switches to make them safety switches, and a great deal has been brought out about the ability of the switch to break the circuit; but I have not heard anything about the ability to make a circuit complete. I think it is just as important to have a switch that will necessarily get contact when it is put on. These switches are usually boxed up so that the operator can not see them, and if a switch only touches on the contacts he is certainly going to have heat if it carries any kind of a load. I think that is a point that should be brought out in all the switches.

***H. W. Moser, Electrical Engineer, The Ballinger Company, Philadelphia, Pa.:** In laying out our equipment in buildings, we try to get an equipment that will be safe for those who have to operate it and be around it. I have in mind particularly a condition that existed in a factory where we changed over some equipment. They had some 550-volt equipment, and on some of the motors they simply placed the open switches about four to six feet high on the walls, and then they passed their trucks along there. Just before we went into that factory they had bumped against one with an iron truck; the result was a small fire; then they wondered why the switch was not satisfactory. We changed that over for them, and after changing it over they had practically no trouble. We also changed a number of switches of a similar character, and by so doing we eliminated one of their greatest troubles: namely, the shockings, not always very serious but at least not very pleasant, of both male and female workers. I cannot say much about the large switches, because we do not use many of them. But the smaller switches we found very successful in that line of work. As to price we have found the same thing —to get a switch that is really good the price goes up so high that very often it is practically prohibitive and we cannot use it.

***Mark R. Woodward, Assistant Chief Engineer, Lehigh Portland Cement Company, Allentown, Pa.:** We have had a little experience with safety switches but have not paid much attention to the question of buying a switch that would be as cheap as the old style knife switch as our primary object has been to protect the workmen.

We have taken the attitude that when you call in the doctor you do not have to protect him against contagion, and skilled electricians will look after their own safety, keeping each piece of electrical apparatus in such condition that the ordinary workman is protected.

With that end in view some years ago we bought the best switch that we could find and after trying it out, discovered that it had mechanical details that were not entirely satisfactory. Then another switch came on the market which we thought would overcome these troubles. It was certainly made so well mechanically, and electrically, that it looked as if it was about right. These new switches worked fine and we thought we had solved our problem, until one day, someone tried to open one in order to disconnect a motor. The controller of this motor was out of order and it could not be shut down except with the load on it. No doubt many of you here have had the same experience and know what happened to the switch. That was an expensive switch; it was a relatively expensive one when we bought it and was more expensive from the results we got when we tried to open it.

Then we began searching for a switch which would be safe for our workmen, even if it must be opened under load, and located one which promised this kind of protection. We put in a few such switches, which proved satisfactory in test, and hope that our trouble may be overcome. We find that each time we change to a new type switch the new one we buy is more expensive than the one we were using.

I am heartily in accord with what a previous speaker said: that we need a safety switch that will be safe for the man who is to operate it, and which will permit him to use it for the purpose for which it is intended: namely, to disconnect his line, and in case of emergency to use the switch to break the circuit even though there is a load in the circuit. We think we have a switch now that will do that and so far the experience we have had with it is satisfactory. But, as with previous switches that we also thought were good, only time and a thorough trial under the adverse conditions of dust and dirt and emergency operation will tell whether or not that problem has been overcome.

***H. Cosdon, Electrical Engineer, Midvale Steel & Ordnance Co., Nicetown Plant, Philadelphia, Pa.:** I feel that we want an enclosed switch that the operator cannot get into while the switch is in the "In" position, but is accessible to the repairman to see if the switch is all right without any disturbance of service. There is another feature we desire; in case of trouble in the switch where the repairman may have to disconnect the live lines and take the switch down for repairs the enclosure should be removable around the live parts. This is one of the bad features with most safety switches today—he cannot do it with safety. It looks as though the manufacturers are working toward protecting the repairman; and if this can be done on small switches as well as on large ones, I think a satisfactory switch will be produced for steel mill use.

***George W. Richardson, Electrical Engineer, American Bridge Company, Pencoyd, Pa.:** Our main trouble with safety switches has been perhaps a bolt or screw would be pulled out leaving one blade in, as they are only held in place by one screw or one bolt. I think if they would built them to have two bolts or screws two would not break as easily as one; we find they break. They do not look like they were going to break but after they get in service awhile, with everybody handling them the way they do, we find they break—not only break screws, but the angles on them. We have had two accidents relative to a man getting shocked by angle or bolts breaking off and allowing one blade to stick in. He thought the switch was open. That has been the main trouble. We had one fellow find his switch was not open after he thought it was open, and he opened the door and tried to pull the blade out with his fingers. He burned his fingers. But these accidents will happen. That man, perhaps, was not educated to not touch it, but nevertheless you will find the men that way. I remember a time, myself, and I have been working around the electrical game since 1880, that you will forget once in a while. I have opened the field circuits while holding the ends and I felt it. We will forget once in awhile. I believe the time is coming when we will get a safety switch which will work all the time, and at some nominal price at which we can afford to buy.

***A. H. Allen, Electrical Engineer, Liberty Building, Philadelphia, Pa.:** I feel that the time of knife switches, as a safety switch is past; I do not think connection development is going to increase along this line. I think the safety switch, as I see it, is the magnetic switch in preference

to any knife type of switch. That suggestion has been brought out by one speaker and appeals to me as along the proper lines. I believe fuses are also undesirable. I cannot see where fuses and the renewing of fuses with the difficulties, which you have and particularly if there are any live contacts or any possibility of live contacts, is a desirable feature, from a safety point of view. If we eliminate the fuses, then we come to some overload protection such as relays; they may be magnetic relays or thermal relays. The question of a magnetic relay at once brings in the question of the time element of that relay and your no-voltage protection. Relays, as a rule, are connected in series with your no-voltage coil, which, in turn, is connected across one of your phases. Your time element, in case the wire is broken on the phase which is not connected up to your no-voltage, gives a time element which is sometimes disastrous from an operating point of view. In other words, you have got to work through your relays before your no-voltage release acts, and sometimes that time element is so excessive as to cause injury to the motor. Another thing, that does not give you phase protection. I am speaking mostly of alternating current, because that is more prevalent than direct current. I think it is very important that a safety first protective device should be of such character as will protect phases as well as overload and no-voltage release. At present, there are comparatively few overload protective devices which give you phase protection as well as overload protection. The question of selection between an electrical overload and a thermal overload is a very interesting proposition and one which, I think, needs a good deal of development and experience to determine which is going to be the most desirable. Personally, it appeals to me that the thermal type is preferable to the electrical type, for the reason that you can generally get a thermal protection on each phase which acts independently; and for that reason it gives protection against single-phase operation.

What the Manufacturer Furnishes as a Safety Switch

And the basis for the design and construction of different makes of switches that provide protection required by users and regulating authorities

Leon H. Frank, Mutual Electric & Machine Company, Detroit, Mich.: Many accidents occur to the practical electrician and maintenance man that are not always due to carelessness but the hazard of his trade. The electrical maintenance man looks on his job in about the same light that the fireman or policeman looks on his job. The fireman considers it his duty to put out fires; the policeman considers it his duty to apprehend the criminal, and the electrical maintenance man considers it his duty to keep the electrical equipment going so as to avoid shutdowns in production or to reduce the time of these shut-downs to a minimum. The electrical maintenance man considers the risk of injury he runs as secondary to the duty he performs and for that reason he often makes temporary connections or bridges around injured apparatus so as to keep the motors running and lights burning until the proper time is found to make the necessary repairs properly and in the manner in which they should be made.

Safety switches which do not take into consideration the fundamental character of the electrical maintenance man's job are, in my opinion, dangerous switches to install.

Considering the question of installation of safety switches, from this point of view, I have outlined below what I consider to be the essential ten points which make enclosed switches really safe:

1—A switch superior in design and workmanship. This requires switches of type "A" or milled and soldered construction. Punched-clip or type "C" parts should not be used in safety switches.

2—Positive quick-make and quick-break construction so that the switch must be in the fully opened or fully closed position and so as to reduce the arc.

3—Interlocks, which prevent access to other than qualified persons.

4—Provisions so that qualified electricians may have access to the switch for inspection in any position.

5—Omission of all features, such as guards or shields which must be removed to allow inspection, and militate against frequent inspection.

6—Ample room within cabinet:
- (a) To permit the proper connecting up of the switch in a minimum of time without damaging the cable insulation.
- (b) To prevent arcing of the switch to the grounded cabinet.
- (c) To allow for the expansion of gases formed by the arc in opening the switch under heavy overloads.
- (d) Working room for maintenance men to make repairs.

7—Removal from the zone of the switch of all loose operating parts such as springs, links, and levers which may get loose and fall into the switch.

8—Most important of all! The blade construction should be of such a design that it is impossible under any condition for any one of the blades to remain in contact when the switch handle indicates that the switch is in the "off" position. Switch blades which depend on clamps, rivets or screws for fastening them to the cross-bar have failed and do fail to come out, and in some instances with extreme danger and serious results. In other words, the switch fails in its chief function—to fully open the circuit.

9—The design of the enclosing cabinet should be of such a nature that on the opening of the door (which should be restricted only to qualified persons) all the operating and current-carrying parts of the switch should be visible so that in the replacing of fuses, etc., to a certain extent, subconscious inspection is possible at that time.

10—The use of springs in switches naturally incurs additional maintenance since springs may be inferior or develop imperfections after a short period of use. The opening and closing of a switch should not be wholly dependent on springs. Springs should only be used to accelerate the action.

H. E. Campbell, Secretary, Union Electric Manufacturing Company, Milwaukee, Wis.: The primary function of a safety switch is to provide a means of switching a motor or circuit on and off which will reduce the fire and accident hazard of such switching to the very minimum. Practically all so-called safety switches are safe if installed and operated in accordance with the manufacturer's ideas. In practice, however, a safety switch is not safe unless it is practically impossible to install and operate the switch except as intended by the manufacturer. If the safety features can be removed or manipulated without interfering with the operation of the switch, it fails of its purpose. If the safety features cannot be removed or manipulated without rendering the switch inoperative, then it is in fact a safety switch.

G. E. Palmer, President, The Palmer Electric & Manufacturing Company, Cambridge, Mass.: In general any piece of apparatus having such construction details as to effectively prevent contact with current-carrying parts or which shield the operator from the hazards incident to the operation or control of electrical circuits may be properly rated as a safety device. Electrical switching hazards are reduced to a minimum when the switch is surrounded by an effective inclosure and operable without opening the in-

closure. Where the switch is combined with a fuse, external operation should be provided so as to permit safe switching operations, and the device should be provided with further construction details that permit the fuse being inspected or replaced by the ordinary workman without the exposure of any current-carrying parts with which he may come in contact when in close proximity to the inclosure itself. The inclosure of live terminals in a grounded box increases the hazards to the operator who has occasion to touch these terminals when alive, if he may also come in contact with the box when so doing.

In other words, a safety switch or a safety fused switch can be properly so called only when the device embodies those construction details which provide for the ordinary workman immunity from shock or burn in the performance of any business that he may have with the device.

It is important that the device include construction details that will permit an inspection of the switch and fuse in either the open or closed position, but if this is considered of more importance than the safety of the persons whose business it may be to operate the switch or replace the fuse, and who would not be deemed competent to inspect or repair live contacts in a grounded inclosure, it is fallacious to rate the device as one providing safety to the unqualified operator.

L. L. Brastow, Sales Manager, The Trumbull Electric Mfg. Co., Plainville, Conn.: There are certain fundamental requirements in dealing with safety in switches. I like the expression "Safety in Switches" better than "Safety Switch." The article itself is a safety switch. The cause it serves is safety in switches.

Incidentally this point is missed by a good many who buy and sell and manufacture safety switches. From our standpoint safety in switches begins first with the switch. This is a point overlooked by the great majority of people, I am afraid. So much discussion has been given to the question of box construction and box classification with this or that minor feature placed as a talking point or with a propaganda purpose in the foreground that the main argument in the whole situation is overlooked.

It is switches we are selling and others are buying. It is the switch that does the work. It is the switch that gets the abuse, and that goes wrong when unable to stand the strain put upon it.

In open knife switches it was possible to notice heavy arcing, to notice a loosened screw or wobbly hinge post, or a poor contact, and correct it. But when a switch is in a safety box, locked up and working continually with very little supervision, there is needed in boxes the highest possible type of switch construction, mechanically and electrically super-efficient. A man does not buy a screwdriver because he likes the shape of an insulated handle, but buys it because the metal is strong and will stand the pressure he wishes to give it. It will not twist in the handle. In other words, it is a good screwdriver and does its work. He wants insulation, but is buying a screwdriver.

The safety switch in the earlier days unfortunately got into the box class. Everybody was talking about the handle on the outside. The boxes were more thought about than the switch itself.

It is with this in mind that in our standard boxes for industrial work we have placed a heavily constructed, rigidly built, carefully aligned and assembled switch, machine-made, built-up with contact and hinge jaws sweated and pinned into foot blocks. The Underwriters' specifications call only for such and such sliding and bolted contact area, such and such separation between parts and side of the box, but have nothing whatsoever to say as to the workmanship and the points of refinement which make a switch a real switch. The detailed attention paid to a knife switch, machine-work, alignment and assembling, is the all in all in a switch. This is what makes a difference in price between cheap switches and a good switch.

In considering a safety box, in the first place, it should be something more than externally operated. A safety switch is always externally operated, but an externally operated switch is not necessarily a safety switch. A safety box should in some way be constructed so that it is impossible to open the box when the switch is in running position and not possible to close the switch until the cover is down, although it is very desirable to have the interlocking catch so constructed as to make it possible for an expert to examine the switch under load. There are variously designed boxes presented to the trade. In determining, however, the kind of box that should be used and in building a complete line of safety switches uniform in design and simple in construction, one must be careful not to get into a complicated mechanism, more or less unimportant, that is apt to become inoperative.

It is very desirable to construct a box that can be used for all amperages, say from 30 to 1200 amp., when such larger amperages are needed. There is no objection to putting 30 or 60-amp. or perhaps 100-amp. switches in a certain kind of complicated box which may have unique features that will appeal to a certain number of the trade, which procedure is very likely a good one for the industry because it satisfies certain engineering ideas and finds an echo in certain of those among the trade.

Our position is somewhat different because we are making a complete line covering all types for all possible standard requirements. We sell in every state of the Union as well as abroad. We studied long to get a design of box that would be suitable for all types and sizes of switches, and as above mentioned we make our switch absolutely safe as far as our experience of twenty-three years in switch construction has given us wisdom and we never have known of any accident on any of our switches due to error in design of our box or of our switch construction. We have had faults and troubles but none has been due to the construction of our switches or boxes. They make for absolute safety, but because we, as others, are subject to the human element and an occasional fall down in raw material sent us certain troubles have happened. But, to repeat, never because of fault in design or construction.

Charles A. Robinson, Super-Safety Switch Company, Chicago, Ill.: Herewith are what I consider the ten essential features of a safety switch.

1—Dead front.
2—Automatic disconnection of fuses and contact members from all sources of electrical energy before they can be touched.
3—Complete insulation of all current-carrying parts and their separation by such insulation from the steel cabinet, with consequent impossibility of grounding through the person operating the switch.
4—A design such that the switch proper is safe independently of door or cabinet.
5—Elimination of live fuse terminals.
6—Provision for testing of fuses while the switch is on.
7—Multiple contact with maximum area and self-alignment to secure the full value of contact, with consequent reduction of draw of arc to a minimum.
8—Simultaneous make and break of all poles on both sides so that all phases will be opened simultaneously.
9—Automatic locking of the switch with the door in open position, rendering it necessary that the door be closed before the switch can be operated. Also means by which the switch can be locked in the open position from inside without key but with added security of a padlock on the door.
10—Construction such that back feed into fuses is impossible.

A. P. Ball, Assistant General Manager, Square D Company, Detroit, Mich.: The primary function of an electrical switch is, of course, to serve as a means of completing and interrupting an electrical circuit. An enclosed safety switch, however, has two additional important purposes: First, it must protect from shock, burn, and loss of life. Second, it must protect from fire or loss of property.

The essential points of construction necessary to accomplish the first purpose are as follows: The switch should be completely enclosed in a metal box with provisions for grounding. Should the box by

any chance become live, it would be dangerous to human contact if it were not grounded. It should be designed to be externally operated. This avoids any possible contact with the live parts within.

The removal of fuses should only be possible when the switch is in the open or off position. The danger from flashes, arcs and accidental contact in removing fuses while the circuit is on, is so great that it should be made impossible.

It should be made possible to lock the switch in either the off or on positions. This avoids the possibility of having the current thrown on and a machine suddenly put into operation when such action might endanger the life of someone or ruin the machine.

The switch box cover should be interlocked so that it cannot be opened when the switch is on nor the switch thrown on when the door is open. This avoids the danger of having inexperienced operators exposed to contact with live parts.

A disabling feature of the interlocking device is desirable so that authorized persons may be enabled to open the cover of the switch while it is on and also to throw the switch on while the cover is open. This enables inspections to be made by those authorized to do such work. This disabling feature can best be accomplished by means of a key, issued only to authorized persons.

Live parts should be covered or hidden even though the cover is open. This may be accomplished by means of insulated hoods over the jaws which allow entrance and egress of the blades through a narrow slit but prevent any accidental contact.

To render protection from fire and property damage, the following points should be observed:

A safe spacing should be maintained between live parts of opposite polarity, and also between live parts and the ground to prevent flashing and arcing.

High-quality insulating material should be used, having a great dielectric strength and low absorption of moisture, in order to keep the current confined within its proper channels.

A rugged mechanical construction is desirable to stand the rough usage encountered in actual service.

A quick make and break feature should be used to insure full contact when the switch is on and instantaneous break when it is thrown off. This is usually effected by means of springs which exert a tension sufficient to move the blades in or out with great speed, regardless of the speed with which the handle is operated.

All springs should be either enclosed in protective housings or so designed that if breakage occurs, they cannot touch live parts and possibly cause a short circuit.

A switch should be completely enclosed so as to confine any possible arcs to the inside of the metal box and so prevent accidental ignition of inflammable material.

By the observance of all these points, the safety switch can eliminate all the dangers of the open knife switch and will increase efficiency in operation and conserve human life and property.

C. J. Zigler, Electrical Engineer, Z & H Mfg. Company, Chicago, Ill.: The question "What makes a safety switch safe?" is answered emphatically and briefly by saying **simplicity.** From the writer's experience along this line, which dates back to the year 1909, we had as our objective in designing our first safety switch the elimination of opening the door to operate the switch, thereby keeping the operator from coming in contact with the current-carrying parts. At that time it was also found that the unusually large cabinets that were used to mount switches in were the most inviting places for the operator to stow away keepsakes which when wanted required the opening of the switch cabinet to get them. In any number of cases this has been responsible for accidents both to the man and to the circuit.

The first requirement, that of operating the switch externally, was made manifest when a simple but rugged operating means was provided with the handle on the outside. Second, the keepsake feature was first overcome by providing a simple means for locking the door when necessity required it and also by the Underwriters' Laboratories Inc. specifying sizes of switch cabinets.

It has long been known that the safety switch when properly constructed is more than just a safety device. It has become an indispensable industrial asset, as many features other than safety are afforded, but to make this statement manifest **simplicity** and **dependable material** must be adhered to.

High initial and maintenance cost are inevitable when complicated mechanisms are employed. And ultimately hazards are added rather than eliminated. Evidently I am of the firm belief that to make a **safety switch safe,** it must be made simple and rugged.

Geo. B. Wadsworth, President, The Wadsworth Electric Mfg. Co., Covington, Ky.: The construction of a safety switch should be such as to completely eliminate the possibility of any form of danger that might occur from the use of such a switch. Our belief is that there are but two vital sources of danger from an electric switch. One is personal injury and the other is fire. So, accordingly, we must arrange fortifications against the possibility of these two items.

To eliminate as far as possible the fire hazard, the switch should be enclosed in a non-combustible enclosure, completely enclosed at all times. Such enclosure would minimize fire hazards. To eliminate personal injury, the enclosure should be so constructed as to completely eliminate the possibility of a person coming in contact with a non-insulated current-carrying part in any normal operation of the switch, with a further provision that would guard against improper assembly of the switch.

After we have accomplished this, together with the conditions above named, we see no reason why such switches should not be classed as a full safety switch.

We do not see any reason why the public should be confused in determining the difference between an enclosed switch and a safety switch. The enclosed switch is not constructed with any exact provision for maintaining the cover closed, or any particular guard against a person handling exposed current-carrying parts while renewing switches, which is an essential operation of any standardized switch, and if the cover is not closed, the fire hazard exists. If a person is exposed to live parts while renewing fuses, the personal injury hazard has not been removed. Accordingly such switches are not entitled to the name **Safety Switches.**

Furthermore, it is our opinion that definite action should be taken on the part of inspection of public safety departments to guard against persons being impressed that such enclosed switches are **safety switches.** The untrained user might be deceived and led to serious injury by the confidence set up by switches bearing the name **Safety Switch.** For instance, the untrained user might deliberately open a case, reach his hands into live wire terminals to insert or extract a fuse and in so doing, come in contact with a part that is charged electrically and receive a very severe personal injury.

L. H. Rosenberg, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.: The hazards from an open switch include the following:

(1) Fire from accidental contact; (2) shock from accidental contact; (3) shock from renewing the fuses; (4) burns from opening a loaded circuit or accidental contact; (5) danger from exploding fuses on high voltage, backed by large power; (6) prevention of tampering with the circuit.

The manner in which these hazards are removed, are, first, second, fourth and fifth by enclosing all live parts; third, interlocking access to the switch box when parts are alive; sixth, sealing of the enclosure or interlocking of the enclosure to prevent access in any manner with the parts alive or the bringing out of wires when the circuit is closed, except, of course, in a legitimate manner, and by persons who are duly authorized to do such work.

The above hazards exist always, but to a more or less variable degree depend on the capacity of the switch and the voltage of the circuit. The lower the voltage, the less the hazard from shock and burns becomes. However, except on very low voltages it would appear that full safety is worth while and not uneconomical, as the additional expense is slight.

A. J. Wayman, The Wayman Electric & Manufacturing Company, East Palestine, Ohio: We are very glad, as manufacturers of safety switches, to have the opportunity of giving our opinion on what makes a safety switch safe.

First, the switch should be built to reduce the fire hazard; second, to protect the operator; third, to protect the maintenance man; and fourth, to protect the curiosity seeker or the person not familiar with electrical devices.

A switch to accomplish these purposes must be constructed along the following lines: An inclosed switch, externally operated. When the switch is closed the door or cover cannot be opened, and when the door is open, the switch cannot be closed. A spring attached to the switch so that it will make a positive quick make and break prevents the switch from making only a partial contact and also reduces the arc when opening the switch. The live parts should be protected so that when the switch is open a person cannot come in contact with same.

In case the quick make and break spring should become broken, it should not prevent the switch from being either opened or closed, or in other words put the switch out of commission.

To make a switch easy to install, the switch box should be in two parts, so that the sides and ends can easily be removed from the bottom of the box. This feature makes the enclosed switch as easy to connect up as an open knife switch, and it also protects the maintenance man when he inspects or repairs it since he can remove the part of the box that interferes with the accessibility to the working parts of the switch. It allows him to make quick adjustments, and without danger of becoming grounded on the sides of a deep box.

The interlocking feature should be of such a type that anyone in authority can close the switch when the door is open. Furthermore, the switch and parts should be ruggedly built and have as few working parts as possible. This will insure long life with a low upkeep.

Earl L. Thomas, Sales Manager, Aurora Steel Products Company, Aurora, Ill.: The following factors are considered necessary in safety switches:

1—Must be externally operated.
2—Provision must be made for locking switch open.
3—The box must be constructed in such a manner as to reduce danger from gas and fire if a short circuit occurs.
4—The switch proper must be constructed with proper spacing between the poles.
5—No springs or bars can be loosely attached inside the cabinet.
6—Cabinets should be constructed from steel which is sufficiently heavy to prevent flimsiness.
7—An arrangement should be made whereby the switch box cannot be opened when the switch is closed.
8—The switch box should be constructed in such a manner as to prevent closing the switch when the box is open.
9—Adequate wire spacing should be provided inside the cabinet.
10—The base of the switch itself should be made from a material that is substantial in every way.

Repairing and Rebuilding Electrical Equipment

(Continued from page 388)

and material sheets, Group *A*, Fig. 3, for that job. We can thus tell at any time just how much material has been used on a job.

The workmen make out a daily time ticket, Group *C*, Fig. 3, and a weekly time ticket, Group *C*, Fig. 4, showing the amount of time spent on each job. The use of a daily and a weekly time ticket gives us a double check on the time spent on jobs and thus prevents errors. The number of hours spent on a job is also entered by the cost department on the labor sheet, Group *A*, Fig. 3, for that job.

If, when a job is completed, the foreman finds that more material was drawn from the storeroom than was needed, he fills out a *Returned Material Credit Memo.*, Group *B*, Fig. 4, and sends this with the excess material to the storeroom. At the same time he notes in the lower portion of the proof sheet, Group *B*, Fig 5, the amount and kind of material returned. After checking over the returned materials, the storekeeper makes out a credit memo, Group *B*, Fig. 2 describing the amount and kind of material returned and sends it to the cost department where it is attached to the labor and material sheet, Group *A*, Fig. 3, for that particular job. Lastly, the foreman turns in his proof sheet, Group *B*, Fig. 5, to the cost department. The material requisitions and the credit memos are checked against the proof sheet to see that they agree, thus accounting for all material drawn from stock and insuring that neither more nor less than the proper amount of material is charged against the job.

Before a job leaves the department it is, of course, carefully checked by the foreman to see that the work has been properly done. In the case of rewound armatures about six times normal voltage is applied to detect grounds or shorts between coils and between coils and iron. Alternating current and a set of telephone receivers are used in testing for grounds and shorts between coils.

Before it is assembled, after all of the repair work is done, every piece of repaired equipment is refinished. For example, in the case of motors and generators a coat of Sherwin-Williams air-drying black lacquer is sprayed on the coils, the frame is given two coats of a good paint and all of the brass and copper work is polished.

Before motors or generators are shipped to a customer they are sent through the testing department where they are carefully tested and inspected to make sure that they are in perfect condition. In the case of a motor, readings are taken of the current and speed at no load and at full load, the kind and size of brushes used is noted, connections are checked up, and so on. All of this information is entered on the record card shown in Group *C*, Fig. 2. These cards, which measure 6 in. by 4 in. are filed in the testing department.

A complete description of the machine, with report of the examination, is also made in the form on the back of the yellow shipping ticket. This report form is shown in Group *A*, Fig. 8. This report is made in copying ink and an impression is made on the tissue sheet which is placed in the correspondence files.

How Do You Like My Stuff?

It's been some time since the editors have given me a place among the leading articles and I want to take this chance to ask you readers a very personal question —How you you like my stuff?

Be honest and refer to the first text page (in this issue it's 375), question and answer section, the jingle rhymes, such as the "Coil-Windin' Man," "He Cannot Read His Tombstone When He's Dead" and anything else.

If you want more of my stuff you will get it but if you want something instead, you will get that too—you're the doctor—what do you say?

Practical Pete

Some Symptoms of

Transformer Troubles—

Their Diagnosis and Remedies

Compiled by H. E. STAFFORD,

Electrical Engineer,
Provincial Paper Mills,
Port Arthur, Ont.

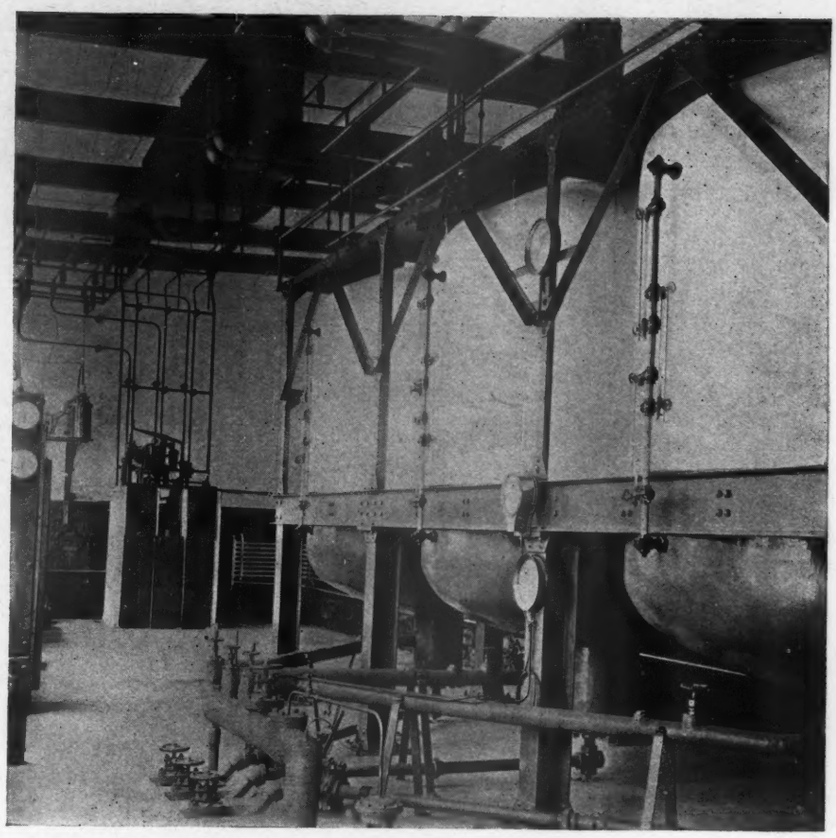
(This table is continued on page 421)

SYMPTOM	TROUBLE	CAUSE	REMEDY
1 Temperature rises to danger point on oil-cooled transformer.	*A* Overload.	*A* Overload or low power factor.	*A* Reduce load or increase the power factor of the system. A 100-kw. transformer at 80 per cent power factor is fully loaded at 80 kw.
	B Not sufficient oil in tank.	*B* Due either to a leaky tank which will be readily noticed or not sufficient oil when transformer was installed.	*B* Add more oil and weld the defective part of tank. (Note: The core and coils should be fully immersed in oil.)
	C Oil jellied.	*C* Excessive heat. In a case of this kind the windings may be roasted and the insulation ruined.	If insulation is not damaged, flush the tank with new oil until all the old oil is removed and refill tank with fresh oil.
2 Temperature rises to danger point on air-cooled transformer.	*A* Overload.	*A* Same as cause in symptom 1.	*A* Same as symptom 1.
	B Not enough volume of air.	*B* Blower speed lowered or air ducts clogged.	*B* Speed up blower, clean out air ducts. (Note: In cleaning air ducts care must be exercised. If compressed air is used do not impress full voltage on windings immediately after, as there is always more or less moisture in compressed air. Half voltage should be impressed on low-tension windings and the high-tension windings short circuited. A transformer thus treated may be put back in service in about five hours.)
3 Temperature rises to danger point on water-cooled transformer.	*A* Overload.	*A* Same as symptom 1.	*A* Same as symptom 1.
	B Not enough water flowing through cooling coils.	*B* Pressure low or some obstruction in pipes.	*B* Increase rate of water flow.
	C Oil level below cooling coils.	*C* Oil leakage around water inlet.	*C* Stop leak and fill tank with fresh oil which should fully immerse cooling coils.
	D No water flowing through cooling coils	*D* Cooling coils plugged.	*D* Remove obstruction with water or air pressure up to 250 lb. per sq.in. but no more, as the coils are likely to be damaged. Where water contains lime or other impurities, the cooling coils should be cleaned at least every six months with a solution of equal parts of pure water and hydrochloric acid. This solution should be allowed to stand for not more than an hour and afterwards flushed with clean water.
	E Oil saponified on outside of cooling coils.	*E* Transformers operated at too low a temperature.	*E* If oil does not soften by over-heating, the cooling coils should be removed and scraped.
4 Explosions occur in transformer tank in addition to the above symptoms.	*A* Short circuit between adjacent layers of high-tension windings.	A^1 Moisture in oil (or air in case of air-cooled transformer.) Moisture in oil may be due to a leak in the cooling coil or to "breathing." Breathing or sweating is caused from operating the transformer in a damp location at too low a temperature. (Note: The temperature of a transformer should not fall below 10 degrees centigrade.)	A^1 Test for moisture in oil. This test may be made in two ways. The first is to measure the break-down voltage required to force a spark through a gap between two 1-in. disks immersed in the oil. Oil that is free from moisture should stand a break-down test of 25,000 volts when the disks are 0.1-in. apart. Where this apparatus is not available, the following test can be made. Heat a few crystals of copper sulphate (blue vitriol) on a hot plate, until the crystals turn white. Take a small bottle and fill with oil from the bottom of the transformer tank, as this is where the moisture will collect, and drop a few grains of the heated vitriol in the oil. Shake well, and if there is any moisture whatever in the oil, the solution will turn blue. If there is no moisture, the solution will remain a natural color. In getting a sample of oil, the best method is to use a long glass tube. Close the end held in the hand by placing the thumb over the opening. When the tube is fully immersed remove the thumb and allow the tube to fill. Again place the thumb over the top opening and withdraw, and the oil will stay in the tube. If moisture is present pass the oil through a filter press. After all the oil has been taken out the tank should be flushed with clean oil. The oil can be replaced as soon as filtered and the transformer immediately put back in service. (Note: Before testing the oil for moisture the transformer can be cut out of service and the service resumed on open delta if transformer bank is connected delta. If star connected all transformers in the bank become inoperative. When operating transformers on open delta, the load should be reduced to 58% of the load carried by the original bank.)
		A^2 Insulation broken down.	A^2 Replace sections of winding causing the trouble.
		A^3 Insulation punctured due to line surges.	A^3 Same as above.
		A^4 Shifting of coils due to switching on and off of heavy loads.	A^4 Same as above.
		A^5 Not enough insulation on the end turns. These should have from 2 to 5 times greater insulation than the inside turns.	A^5 Same as above and reinsulate end turns to proper thickness.
		A^6 Electromagnetic stresses too great, due to improper core construction.	A^6 Transformer will need to be sent to factory, to be redesigned. This trouble will be seldom met with.
		A^7 Transformer coils not properly baked before assembling.	A^7 Short circuit primary or high-voltage windings and impress about half voltage on low-tension windings.
		A^8 Lightning discharge without protection.	A^8 Repair damaged coils or replace with new coils. (Note: All transformers should be protected by having choke coils or reactors in series with them.)
		A^9 Oscillating currents caused by conductors swinging together due to wind storms.	A^9 Same as A^2.
		A^{10} Unstable voltage, generator voltage not steady.	A^{10} Same as A^2.

ONE MAN PER SHIFT does all the work in connection with two 2,500-boiler-hp. electric boilers for the Laurentide Company, Grand Mere, Quebec. Formerly thirty-seven men were required to get the same amount of steam (75 tons per hour) from fourteen coal-fired boilers. In addition the handling of 50,000 tons of coal per year is eliminated.

New Uses of Electric Steam Boilers

And the Results Secured in Several Mill Installations



One man handles these three 1800-boiler-hp. electric boilers which operate on 22,000 volts. These boilers take three-phase, sixty-cycle energy and evaporate fifty-five tons of water per hour at 125 lb. pressure for the Brown Company, Berlin, N. H. This is the highest voltage at which any steam generators operate. Each set of three units is rated at 18,000 kw.

By P. H. FALTER

Vice-President, The Electric Furnace Construction Co., Philadelphia, Pa.

UNDER CERTAIN conditions the electric steam boiler is an economical means of making steam. The main condition for successful operation is that cheap electrical energy be available during at least part of the time.

This energy may be surplus power purchased under a block rate but not used. With such conditions the money saved on coal may often pay for the electric boiler in a short time. A boiler of this type requires no heavy foundation or a large building. It has no smokestack and no fuel storage, handling or stoking. The operation is simple and requires few men. There is no smoke, dust or ashes. The boiler has a thermal efficiency in the neighborhood of 97 per cent and it will generate steam at any pressure. The repair charges and stand-by charges are quite low. Refractories and other parts subject to high temperatures are eliminated since the highest temperature is that of the steam.

The accompanying table shows the range of voltages, capacities, sizes, and so on. Alternating current at 220 volts up to 22,000 volts has been used on single-phase, two-phase and three-phase systems. Steam pressures varying from 4 lb. to 220 lb. are secured and the boilers supply as high as 100,000 lb. of steam per hour at 125 lb. gage. Water heaters give up to 3,000 gal. per minute raising the temperature 15 deg. F.

The electric boiler generates steam by passing current directly through the water. In its simplest form the water-resistance boiler is nothing but a water rheostat. Such a heater is very nearly perfect in efficiency. All the energy put into the boiler or heater passes into the water. The only losses which are possible are a loss due to radiation, which can be kept at a low value by proper heat insulation and a small loss from bleeding or blowing down to get rid of the impurities left behind when the water is evaporated. The opportunity for inefficiency as a result of carelessness on the part of the attendant or total lack of attendance is very small. A single attendant per shift can easily look after two or three units, since his principal duty is to keep the water at the proper level.

The first boilers of this kind were designed by F. T. Kaelin, chief engineer of the Shawinigan Water & Power Company, together with the writer. On these boilers iron plates bent to the arc of a circle were employed as electrodes. These were suspended from conducting rods within the boilers so as to hang concentric and thus parallel with the neutral shell which formed a protective lining for the boiler shell proper. This construction, while fairly satisfactory does not lend itself to adjustments which are sometimes necessary. Round electrodes were tried, using two or three in a tank, but these are not as satisfactory as the concentric electrodes from the viewpoint of making definite calculations of current distribution. Both of these methods are limited to use in smaller boilers, up to 7,500 kw., and for voltages up to 2,300.

For higher ratings, and particularly for higher voltages, the multiple-tank design is generally employed. This design is equally satisfactory for small boilers, but it is somewhat higher in first cost than the one-tank design. For three-phase power three tanks are used and two tanks are used for two-phase supply. Each tank is a separate single-phase boiler, having one cylindrical electrode suspended from its center by

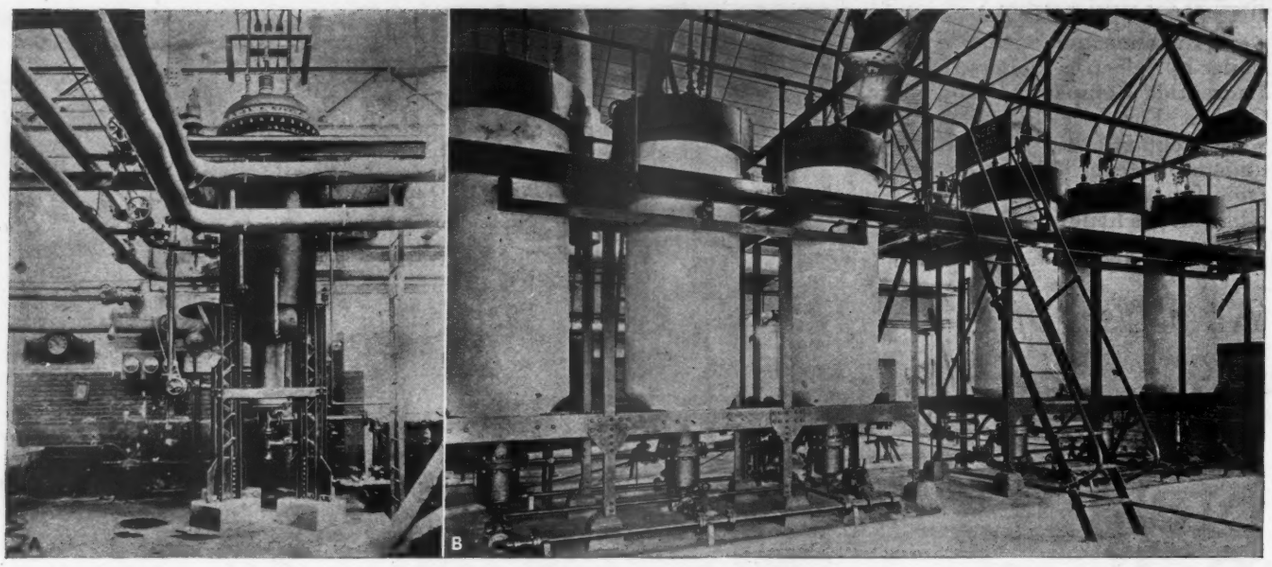


Fig. 1—Two electric boiler installations which produce steam very cheaply.
At *A* is a 5,000-kw. (500-boiler-hp.) unit installed at the Wayagawamack Pulp and Paper Company, Three Rivers, Quebec. The two 25,000-kw. sets at *B* are the largest electric boilers in operation. They operate on 6,600 volts, three-phase, sixty-cycles and each delivers 77,500 lb. of steam per hour at 135 lb. pressure. They are in the plant of the Laurentide Company, Grand Mere, Quebec.

one or more supporting rods or cables which serve to bring in the current. The water supply and bleed for each tank are manipulated independently so as to keep the same amount of power flowing through each tank, and thus balance the phases on a polyphase system. The steam is piped into a common header.

In designing an electric boiler or water heater all boiler code rules and special State regulations must be complied with. The only conditions which limit the design are atmospheric pressure, water-service pressures, and low, standard and high steam pressures. The selection of the correct operating voltage may have an important bearing on the efficiency of the boiler. Also the question of current densities must be properly investigated. A boiler that will meet one condition of water may not be suitable for another. Even the frequency employed influences the design.

Boiler-feed waters vary greatly in electrical conductivity and this must be carefully taken into consideration when selecting the boiler. No chemicals should be added to the feed water for electrical boilers.

The fact that the height of the water in the tank controls the power input and thus the amount of steam generated, renders an electric boiler nearly automatic. For this reason additional automatic control equipment was found merely to complicate the operation without giving any corresponding advantages. Many of the so-called automatic devices have the habit of failing at a critical time and such accessories often require more attention than the main apparatus. On the large electric boilers a man is always in attendance and it is a simple matter for him to keep watch on the water levels.

There is little that can go wrong in a properly designed electric boiler. On high voltages insulators give some trouble and electrode wear must be allowed for. However, voltages as high as 22,000 volts are used with practically no trouble. The wear on the electrodes is usually not over a few inches per year and consequently they do not have to be renewed oftener than about once a year. Of course safety valves are installed on these boilers, but there is also another guard against excessive pressure. Automatic circuit breakers (or fuses for small boilers) are connected in the supply wires and these cut off the current if the pressure goes too high. Abnormally low water which is so much feared in coal-fired boilers means only a lower steam production in the electric boiler and in case the water falls below the ends of the electrodes the current flow in the boiler is simply shut off.

These boilers have been particularly applicable to pulp and paper mills for generating process steam. In general, however, any plant which uses steam and hydro-electric energy might find that an electric boiler is economical for either intermittent or continuous use. Among the industries to which this applies are the pulp and paper, lumber, chemical, laundry, textile, dye, food, cement, fertilizer and others.

Cheap electrical energy is present in different ways in different plants. For instance one plant purchases energy at a block rate paying for a certain amount of power whether it is used or not. During part of the day and on week ends some of this power is not used. Consequently an electric boiler was installed. The present cost of making steam is considerably lower than the cost of making it with coal. In fact the boiler paid for itself in a few months.

As an example of the possible saving suppose a company buying such power has a surplus as follows which is paid for but not used:

100 kw. available 11 hr. each week day; 200 kw. available 12 hr. each week day at night; 300 kw. available 16 hr. each Sunday:

This amounts to:
100x11=1,100 kw.-hr. each week day
200x12=2,400 kw.-hr. each week day at night
3,500 kw.-hr. each week day.
3,500x 6=21,000 kw.-hr. available during six week days
300x16= 4,800 kw.-hr. available on Sunday
25,800 kw.-hr. available per week

If 25,800 kw.-hr. is divided by 7, the quotient, 3,700 kw.-hr., is the average electric energy that is available each day.

Now 1 kw.-hr. will evaporate 3 lb. of water, hence 3,700 kw.-hr. will make 3,700 x 3 =11,100 lb. of steam per 24 hr. In other words, this is the amount of steam that can be gen-

Ratings and Sizes of Electric Steam Boilers

This List Shows the Range in Voltage, Capacity, Size, and So Forth of Some of the Standard Electric Boilers That Have Been Made

Volts	Kw. Normal Rating	B. H. P.	Lbs. Steam Per Hr. At 125 Lb. Pressure	Overall Dimensions		
				Length	Width	Height
550	350	35	1,000	5′ 0″	4′ 6″	9′ 3″
550	600	60	1,750	5′ 0″	4′ 6″	9′ 3″
1,100	800	80	2,300	5′ 0″	4′ 6″	9′ 3″
1,100	2,000	200	5,800	6′ 0″	5′ 0″	11′ 3″
2,200	1,300	130	3,800	5′ 0″	4′ 6″	9′ 3″
2,200	3,200	320	9,300	6′ 0″	5′ 0″	11′ 3″
2,200	5,000	500	15,500	7′ 0″	6′ 0″	13′ 6″
4,400	1,800	180	5,300	6′ 0″	5′ 0″	11′ 3″
4,400	6,000	600	18,000	12′ 0″	6′ 0″	13′ 6″
6,600	8,000	800	24,500	12′ 0″	6′ 0″	13′ 6″
6,600	20,000	2,000	60,000	20′ 6″	11′ 0″	13′ 6″
12,000	24,000	2,400	73,000	25′ 0″	13′ 0″	15′ 0″
22,000	18,000	1,800	53,000	.....	.....	.....

erated in an electric boiler by consuming electric energy that has already been paid for and that would otherwise be wasted.

Assuming that 1 lb. of coal makes 6 lb. of steam this would require 1,850 lb. of coal. At $8 per ton this equal $7.40 for coal per day. Therefore with the electric boiler the saving would be $2,700 per year of 365 days. The cost, f. o. b. Philadelphia, of a 350-kw. electric boiler is $2,500. The installation cost would be $500, making a total of $3,000. The saving on coal would therefore pay for the electric boiler in less than a year and a half.

The electric boiler has made possible the development of certain pulp- and paper-mill projects in Canada and elsewhere, which would have proved uneconomical if coal had been necessary. As an example, which is typical of that practice, we may assume a paper mill requiring 1,800,000 lb. of steam in 24 hours. This will require a boiler of about 23,800 kw. capacity. If this steam were generated by coal giving an evaporation of 9 lb. of water per pound of coal, then 89 long tons of coal would be required daily. At a price of $8 per ton under the boilers this would amount to $712 per day, or $213,600 for a year of 300 days. These figures are entirely reasonable, and in fact are in favor of the coal-burning boiler. If the power for this boiler is available without additional expense the boiler will pay for itself within a few months. It is possible, furthermore, to build a generating plant or enlarge a present one in some cases provided the water power is available. This can be done at a saving over the operation of coal-fired boilers. Let us take for instance the case just mentioned. If we capitalize the annual coal bill as 10 per cent for interest and depreciation it will give us a total capital allowing an expenditure of $90 per kw. installed for the hydro-electric plant to operate the electric boilers. This cost would have to include the transmission line, but neither step-up nor step-down transformers would be required if the generators were chosen of a voltage to suit the boilers. If the transmission line were very short probably much less than $90 per kw. would be sufficient. For instance, at $75 per kw. the electric boiler would compete with coal at $6.67 under the boiler. At $60 per kw. for the electric plant the cost for steam would be the same as for coal delivered under the boilers at $5.33 per ton.

In New England there are many plants which have small streams dammed to develop a small amount of power. Much of this water is allowed to (*Continued on page 422*)

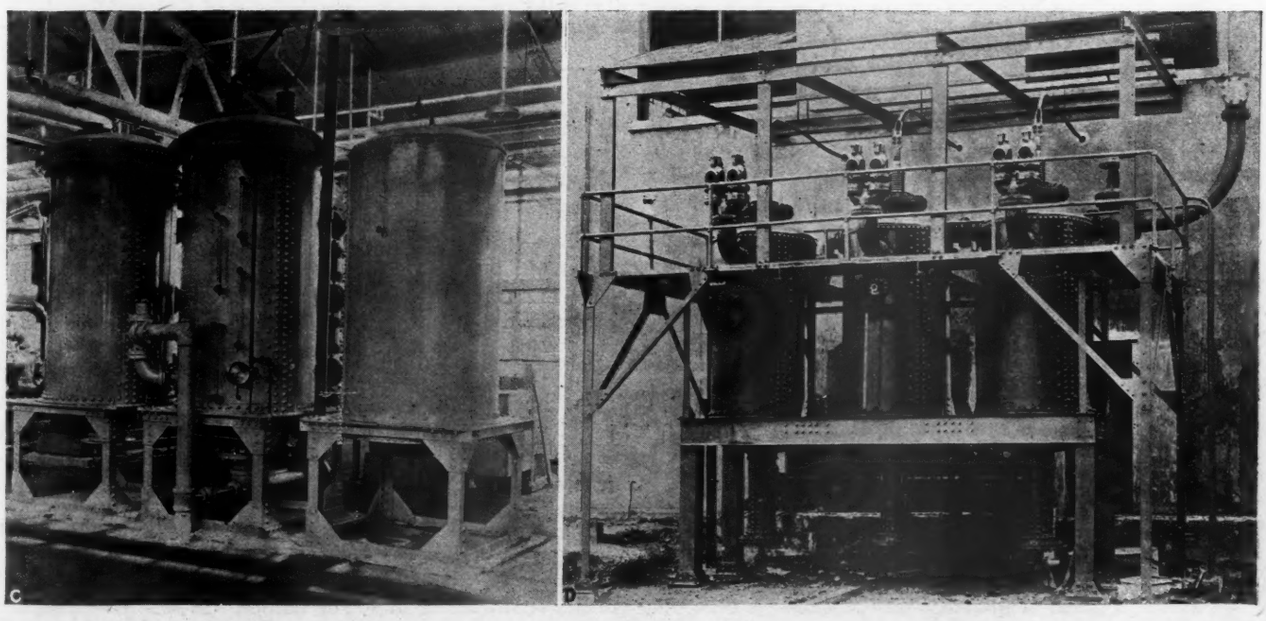


Fig. 2.—A large boiler and a water heater which use electrical energy as the source of heat.

The 1,800-boiler-hp. steam generator at *D* occupies, with its fittings and platform, a space of only 21 ft. by 10 ft. 3 in. by 22 ft. The boiler is rated at 18,000 kw., 12,000 volts, three-phase, 25 cycles and evaporates 54,000 lb. of water per hour at 125 lb. pressure. The boiler is owned by the Niagara Falls Power Company, although it is installed in the plant of the Cliff Paper Company, Niagara Falls, N. Y. At *C* there are shown two water heaters in the plant of the Ford Motor Company, Green Island, N. Y. The heaters are rated at 3,000 kw., 4,600 volts, three-phase, sixty cycles.

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, August, 1923

Have the Courage of Your Convictions!

INDUSTRIAL MEN, particularly those who have dug their practical experience out by hard work and hard thinking, frequently voice their difficulty in putting across their ideas in contrast to others who are better talkers. Sometimes they feel that those in authority try to talk them down and merely offer objections just to be contrary. Such, however, is seldom the case. What are often considered as objections, even though so worded, are usually a sincere desire to find out all about the proposed idea before going to the expense of a trial.

One general manager of a very large enterprise is considered by his associates as a particularly hard man to convince on the practicability of new ideas. One of his younger associates who has been particularly successful in "selling" ideas to his superior, attributes this success to the ability to anticipate any objections, operating conditions or possibilities which might arise in practice and by being able to show how his suggestion would meet it. Thinking ahead will eliminate many false ideas and it is cheaper, and easier, to think than to try costly experiments. Also clear thinking forms the basis of clear argument.

How another practical man who had the courage of his convictions finally won out by persistence is shown by the following letter which was received from a reader with a contribution for the "Service Around the Works" department of INDUSTRIAL ENGINEER:

> I am sending for your approval, a description of the job of which I am the most proud. I don't suppose you can realize the difficulties under which I labored to get permission to make this test. It was turned down by our head engineers, by their consulting engineers and by the engineers who built the equipment. They proved (on paper at least) that the loss in heat in the rheostat would more than balance the saving in power, also that the motor speed would not be stable.
>
> However, I had done this before on a small scale and having the courage of my convictions I kept on and eventually won over our superintendent who agreed to take a chance (on the quiet). Not much was said at the actual test run, but somehow, on pay day, I was not much surprised to find an increase amounting to about 10 per cent of what I was saving for the company. I was recognized at last as "a practical man."

Perhaps other readers have installations of which they, too, are proud and on which they have won out through persistence and clear argument and have received the recognition and reward for it. If so we would like to publish the details.

Progress Follows the Question Mark

THE FIRST automobiles were provided with whip sockets. Finally someone asked *why* and there was no reason except that buggies (the earliest automobiles were adapted buggies) always had been built that way. Almost every farming community tells a true story of a neighbor who is "kidded" about carrying a binder whip after he had hitched his reaper up to a gasoline tractor. He, too, was following habit or years of precedent without asking why.

Recently the Chicago Tribune stated that their business manager asked "Why provide sash locks on windows of a skyscraper?" and thereby saved $1,000 in a hardware bill. Probably he saved an equal amount by eliminating their installation expense on a new building which the Tribune has under construction. After all it is not very likely that anyone will crawl into the windows on the tenth or twentieth floor of a skyscraper.

How many other things are being done every day that are unnecessary? Simply because someone did them that way once is no reason for a habit so firmly fixed that everyone thinks that it is indispensable and must be continued forever.

Men in industrial plants have big opportunities for asking "why" in the work they do. Why is this made in two parts? Why are two bolts or screws required instead of one? Why is the work done this way? Why is it put together as it is? These and many other questions if answered will bring out economies which are essential to keep down the cost of production. Progress results from initiative and a determined effort to answer the question "Why?"

Are You Getting Ready for the Big Job?

"SOME DAY the Big Job will come along and I'll have the answer to it while you fellows are running around and trying to find out where to start." This was the reply of a young repairman to some of his fellow workers who were making sarcastic remarks about the time he "wastes" in filing wiring diagrams and other useful information in a large scrap book, of which he is very proud.

Time spent in collecting and filing information that one may find useful in his work is never a waste of time. Rather, it is a form of preparedness that is probably too seldom practiced, although it is something that no one who is interested in his job and in his future can afford to overlook. Most of us have more than once been suddenly confronted with a knotty problem, and could remember that we had seen the answer to it, somewhere, sometime, but when we needed it we could not find it. Merely to know that there is an answer somewhere does not help much in an emergency. The fellow who wins recognition is the one who knows exactly where the answer is and can produce it whenever necessary.

Technical magazines publish a very large amount of extremely useful information, much of which is the result of years of experience. But, unless the various issues of the magazine are kept for reference, or the tables, diagrams and other usable data clipped and filed, finding them two or three years later—when the Big Job comes along—may be very difficult or impossible.

Strain at a Gnat and Swallow a Camel

EVERY successful business man takes pride in the belief that he gets very nearly 108 cents value, and perhaps more, for every dollar he spends. That is one of the reasons why he is successful. Often, however, he overlooks the fact that the effort he makes to get "his money's worth" when a motor or other piece of equipment is purchased is effective only insofar as the purchase price and the quality of the equipment are concerned. The manufacturer charges a price which is in keeping with the quality and true worth of the equipment and sees that it is in proper working order when it leaves his factory. Whether the purchaser will realize the full value of his investment depends on how the equipment is cared for after it is placed in service.

Practically every item of equipment used in industrial work needs some maintenance attention. Bearings wear down in time, contacts become burned, insulation slowly deteriorates and in a multitude of ways service exacts its toll. Unless this toll is paid in the shape of proper attention and care the purchaser of the equipment cannot hope to secure from it the full service which it is capable of giving, when operated under the proper conditions. He will not get back the 100 cents expended and the 8 cents as a net production profit.

It is highly illogical for the management of an industrial works to make too much ceremony over securing and comparing bids when buying equipment in order to make the best bargain possible, and then, after the equipment is installed, practically forget all about it. In the one case a comparatively few dollars may be at stake; in the other, hundreds or thousands of dollars may be involved.

Straining at a gnat and swallowing a camel evidently is not confined to biblical times.

Things the Eyes Do Not See

OBSERVATION is a great asset that is usually keenest after years of experience and the accumulation of information that automatically causes the eye to make more or less subconscious comparisons. The physician who is a successful diagnostician after years of practice is respected and perhaps trusted more than the younger physician, not so much on account of the difference in scientific training, but because of the larger and broader experience that years of practice have provided.

A fuller knowledge of science has, however, furnished instruments and devices that compete with experience when placed in the hands of an analytical observer. In industrial work the portable graphic recording meter is such an instrument. And its indications are so sensitive and so accurate that things which get past the experienced eye are plainly brought to the attention of one less trained and at a time when this knowledge will make it possible to remedy the trouble thus located, with the least trouble and expense. The use of the graphic meter referred to by Mr. Funderburg on page 375 of this issue in the testing of a geared drive brings out this particular point.

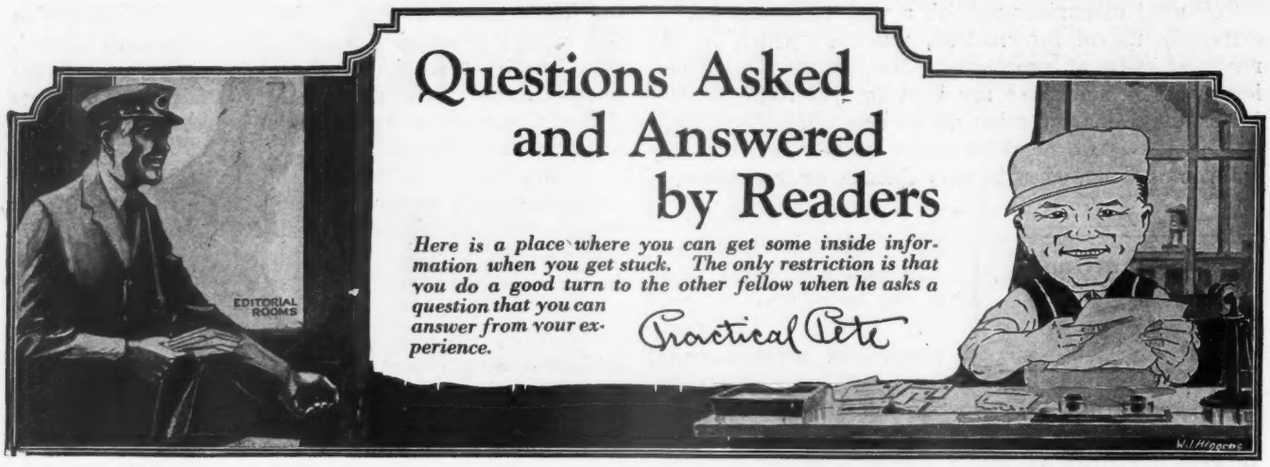
In most plants we have a tendency to be too satisfied with conditions as they are and looking for trouble is sometimes an unpopular job. But after all $200 to $400 worth of testing instruments and a man who knows how to use them at a salary of say $3,600 per year, is an insurance protection against lost time in production, damages to machines, and spoilage wastes, of about 40 per cent when these troubles amount to $10,000 per year and 4 per cent when they amount to $100,000 per year. Even in the first case the prevention of a break in a lineshaft, the burn-out of a 500-hp. motor, or the stopping of rolls in a steel mill, will make the expenditure of $4,000 a year a profitable investment, when compared with the probable loss that might result when operating conditions of machines and circuits are judged solely by inspection with the eye.

Accident Prevention Is Cheap Production Insurance

IN A RECENT bulletin issued by the United States Steel Corporation these significant facts are presented on accident prevention: Since 1906 when intensive safety work was begun, serious and fatal accidents in its plants have been reduced 56.13 per cent and 35,313 men have been saved from serious or fatal injury. Since 1912 disabling accidents have been reduced 71.41 per cent which means that 193,232 men have been saved from injury. During 1922 in 136 plants and mines employing an average of 55,639 men, some operations were carried on from two to six months without a single disabling accident.

In making such records possible something like $12,000,000 have been expended in improving physical conditions of plants and in education of workmen to maintain their interest and co-operation in safety work. At present there are employed 125 safety engineers and supervisors who devote their entire time to accident prevention and the improvement of working conditions. More than 55,209 employees have served on safety committees since 1908 and at present 8,912 employees are serving on such committees. These plant safety committees are made up of operating officials, foremen, master mechanics, skilled workmen and men from the rank and file of the plants who make inspections, investigate accidents, recommend means for preventing similar accident and conduct special investigations of particular problems.

Employees in large plants such as are operated by the Steel Corporation have a right to expect safe working conditions, but they have an individual responsibility as well in maintaining safety standards and in observing safety regulations that have been adopted for their protection. The steel company, like many other large organizations, is making the marked headway outlined through a combination of engineering revision in plant operations and education which shows results in reduced disablement, less time lost and increased production—results which indicate that accident prevention, largely viewed as a necessary humanitarian activity, has also a practical and economic aspect.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Design of a Growler for Testing Armatures—I wish some of the readers of INDUSTRIAL ENGINEER would tell me how many turns and what size wire to put on a laminated core in order to make a growler for testing armatures up to 50 hp. in size. This core is 8½ in. x 4 in. x 4 in., and has a 1¼-in. slot cut into it. If necessary I could make the core longer. Alternating current of 110 or 220 volts is available for operating the growler.
Canton, Ohio. R. M.

* * * *

Removing Insulation from Enameled Wire—I should like to know if any of your readers know of a quick method of removing enamel from magnet wire, other than scraping with a knife. I find it takes a great deal of time for this operation in winding a motor and I would be very grateful if someone can tell me of an easier method.
Avenel, N. J. J. U.

* * * *

Voltage from Transformers Connected in Different Ways—I should like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting transformers open delta, closed delta and star. Please show, if possible, a sketch covering each of these connections and the voltages at 2,300, 1,100 and 440 volts. Perhaps someone can tell me where I can purchase a book which covers such subjects.
St. Louis, Mo. F. W. Mc.

* * * *

Changing Two-Phase Motors to Three-Phase—In our plant we have sixteen motors ranging from 3 hp. to 50 hp., making a total of 210 hp. These motors are wound with four to eight poles. We are considering putting in additional equipment and I shall appreciate it if some reader will answer these questions: (1) Would it pay to change over to a 3-phase system? (2) What saving would there be, if any, in power consumption? (3) Would it be necessary to rewind these motors to change them from 2-phase to 3-phase? (4) Would such a change increase the efficiency of the motors?
Jeannette, Pa. A. W. G.

Testing Series Field Coils for Short Circuits—I wish some of our readers would tell me the best way to test series field coils for internal short circuits. We use 600 volts direct current for power purposes and have no instruments on hand except a 600-volt voltmeter. Whatever outfit or equipment is recommended, will you please state where it can be purchased and what the complete outfit will consist of? I should also like to know if the outfit will prove satisfactory in the case of dead shorts as well as high-resistance shorts.
Albert, W. Va. F. H.

* * * *

Changing Single-Phase Motor to Three Phase—I have a single-phase, 12-pole, 48-slot, 600 r.p.m. exhaust-fan motor in which the running winding consists of 54 turns of No. 17 wire per pole in two slots. This winding is connected in parallel. I shall appreciate it if some reader can tell me if it is possible to rewind this motor for 220 volts, three phase. If so, how many turns per coil should there be? What should the pitch be? Please show a diagram of the connections.
Shreveport, La. G. R. L.

* * * *

Operating Two Direct-Current Generators in Parallel—We have in our plant two 300-kw. d. c. generators. These machines are wound series compound, are equipped with equalizers and are connected in parallel. They are in continuous operation, except that once in 24 hours they are shut down for about 10 minutes for cleaning. We leave the resistance on the shunt field in the same position as when running, as there is no load on the machine. We trip the breakers and pull the equalizing switches out. I should like to know, however, if the machine is likely to be damaged in starting up again in case the engineer should shut down with the resistance fully cut in on the shunt field and both breakers tripped, but with the equalizing switches in. The running voltage of this machine is 250 volts. When starting up with the resistance cut in the machine does not build up the voltage. I should like to know what voltage the incoming machine would build up with the shunt resistance cut fully and receiving its only excitation from the other machine through the equalizer.
St. Louis, Mo. F. G.

Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how the current passes through each meter.
Haledon, N. J. G. Z.

* * * *

Method of Determining Resistance—Will some of the readers of INDUSTRIAL ENGINEER please tell me what method they have found best to determine the resistance in the following cases: (1) When a faint noise is heard when testing for a ground or a short-circuit with a 2200-ohm telephone receiver and 6-volt dry cell what is the resistance? (2) When testing with a 2200-ohm receiver and a 2-volt dry cell? (3) When testing with a 75-ohm receiver and 6-volt dry cell? (4) When testing with a 75-ohm receiver and a 2-volt dry cell? (5) What takes place in a 112-volt Mazda B lamp installed on a 110-volt circuit, when the inside of the glass gets black? I believe a lower voltage was the cause of these lamps getting black but I cannot understand just what chemical action has taken place to cause it.
Philadelphia, Pa. A. C. D.

Answers Received To Questions Asked

Armature Insulation—What is considered the best types of slot insulation that varies from 5 to 10 mils in thickness, considering pliability, mechanical and electrical insulation and deterioration in stock?
Albert, W. Va. F. H.

In answer to the request of F. H. in the May issue for the best type of armature slot insulation, I want to express my opinion. I surely hope that if F. H. is really looking for good material he will heed my suggestion, which is the result of eight years of armature winding experience, during which time I was, and am yet, very much interested in the kind of insulation used.

To my mind, the best all-around

slot insulation I ever used is what is called in the trade Armco paper, made and sold by the Allied Rubber & Mica Company, Cleveland, Ohio. This is without doubt the very best I have used, and I use it now in every possible instance. The next best is what is known as Red Rope paper. These two papers are tough, pliable, hard to tear, good dielectrics, and will stand a lot of hard usage and mechanical stress. The Armco paper is especially useful when winding soft coil armatures, where the coils have a tendency to bulge as they come out the sides of the core, this being where the greatest mechanical strain is and where many kinds of paper will crack.

The Red Rope paper is also an excellent paper, not quite as tough as Armco, but it has the very good property of being easily shaped when used for insulating the core ends, the back of commutators and in the neck of the armature. This paper should be thoroughly wetted and allowed to stand for a few minutes after it is cut to shape. This wetting makes it soft and pliable and it can easily be formed and rolled into shape with a warm rolling iron or piece of steel. As an armature slot insulation I like it next best to Armco, but it has a very fibrous texture that makes a rough-looking job when the papers are cut off at the top of the slot, unless the knife used is very sharp.

I hope F. H. will try these papers and I am sure he will be satisfied. The Red Rope paper comes in rolls and the Armco in 30-in. x 40-in. sheets. GEORGE WM. HANLON.

Darby, Pa.

* * * *

Voltage between Transformer Neutral and Ground—I am looking for information which I am sure some of our readers can furnish. In a primary star connection with the neutral grounded, machine rating 4,000 volts, three-phase between phases, what voltage, if any, would there be to ground when three single-phase transformers of 2300-volt rating are star-connected to the primary side and the secondary side connected 440 volts delta? Also, what would it be if the secondaries were connected 440 volts star on the secondary side?

Elkhart, Ind. R. A. D.

In the June issue of INDUSTRIAL ENGINEER R. A. D. asks what will be the voltage to ground on a 4,000-volt, three-phase, grounded neutral system using 2,300-volt transformers with the primaries connected star and the secondaries connected star or delta.

As R. A. D. has not mentioned any grounding of the transformer, the only grounding being on the supply system, there will be no voltage to ground on the secondaries, but there will be a voltage of 4,000 divided by 1.73=2,310 volts from the primary supply lines to the ground.

So long as the insulation between the windings in the transformers remains intact there will be no voltage from the secondaries to ground.

Boston, Mass. EDWARD A. GIBBS

* * * *

Reversal of Rotation of Watt-hour Meter—There are two questions I should like to ask the readers of INDUSTRIAL ENGINEER.

(1) We have an Ingersoll-Rand compressor, driven by a Westinghouse synchronous motor. When this motor is started by an auto-starter the watt-hour meter will run in a forward direction, but as soon as the switch is thrown into the running position, the meter reverses its direction of rotation. By adjusting the field excitation up to 20 amp. the meter will run forward or in the proper direction, but as we have to run this motor with a field excitation of 35 amp. the meter will again reverse and run backward as soon as this current value is reached. This is a polyphase, watt-hour meter and the power factor never goes below 70 per cent. What causes this reversal?

(2) We are about to install four 300-hp., 2,200-volt, 3-phase, 60-cycle motors rated at 69 amp. per motor, or a total of 276 amp. What size polyphase watt-hour meter should be purchased in order to take care of the four motors?

Iron River, Mich. A. J. E.

In reply to A. J. E.'s question, I believe you will find that your watt-hour meter is improperly connected up, assuming that you have a 3-phase watt-hour meter and not two single-phase meters. At a power factor of 70 per cent lagging it is possible to connect up a 3-phase watt-hour meter so that it will correctly indicate the kw. input, but give an incorrect reading at any other power factor. If you had two single-phase power factor meters connected to this circuit, you would find that one meter will reverse under certain conditions but a polyphase watt-hour meter should run in a positive direction regardless of the power factor.

With reference to the size of watt-hour meters which should be used with the four new motors, it is customary to install a watt-hour meter of rating 50 per cent in excess of the maximum rating of the circuit it is to be used on. This is to take care of heavy starting current and overloads. If the four motors you mention are to be run together, I would recommend a 2,000-kw. watt-hour meter using 500-5 current transformers, but if you want light load accuracy, and the four 300-hp. motors are not going to be started together, I believe you would secure better results by putting in a 1500-kw. meter.

If after checking the connections, both internal and external to your watt-hour meter, you still find that the meter rotates in both directions, I shall be very pleased to give you any further information that you need if you will let me know and if possible show in a sketch the connections as you now have them.

Detroit, Mich. A. C. ROE.

* * * *

Starting Trouble When Rheostat Was Changed—I have a 2-hp., 230-volt motor connected to a drill press. The rheostat burned out recently and I made use of a 5-hp., 115-volt rheostat which was all we had. When starting the motor with this rheostat it ran in the wrong direction. We tried to reverse the direction by changing the armature leads and changing the field leads. This did not change the direction of rotation. The motor is a two-pole type shunt wound. Please advise why the direction of rotation was not changed when changing the connections and also how the direction of rotation can be changed.

Indianapolis, Ind. H. T. F.

With reference to the question by H. T. F. in the April issue regarding the cause of reversal of a 2-hp., 230-volt motor when the rheostat was changed, I think that he must have, in some way, changed the field connection running to the no-voltage release coil on the rheostat. Probably he substituted a rheostat of a different type. Then in changing connections he states that he changed both the field and armature connections. Changing either one would reverse the motor, but it would not be reversed by changing both field and armature leads. A 5-hp., 115-volt starter would give a 2-hp., 230-volt motor very little starting protection.

Manager, C. M. FLUKE.
Raystown Water Power Co.,
Roaring Springs, Pa.

* * * *

In the April issue of INDUSTRIAL ENGINEER, H. T. F. asks why the shunt-wound motor reversed when a new rheostat was installed and why the direction of rotation was not again changed when he changed the position of the armature and field leads.

The cause of the change in the direction of the rotation of the motor was probably due to his getting the leads connected to the rheostat crossed, thus connecting the positive lead to the negative side of the circuit and *vice versa*.

Then when he tried to reverse the direction of rotation he reversed both the field and armature leads, so that the relation between them was unchanged. If he had altered only one set, either field or armature, he would have found that the motor reversed, but it will not do so when both are transferred to the other side of the circuit. G. H. MCKELWAY.
Westfield, N. J.

* * * *

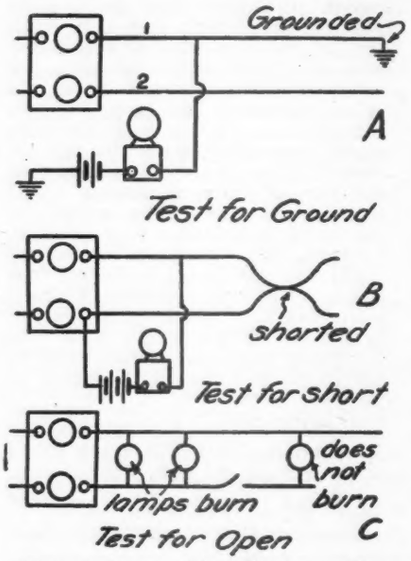
In the April issue, H. T. F. describes a starting trouble which developed when a rheostat was changed. It is really guesswork to try to determine without more details just why the direction of rotation of the 2-hp. motor was reversed, but the following explanation is very probable. I assume that the new starting box was connected properly, the connections checked and that the motor was compound wound.

Suppose that the series and shunt fields had been bucking each other right along, but that the load had never been so heavy that this was discovered. When the 5-hp., 110-volt starting box, which has five times the current-carrying capacity of the 2-hp. starting box, was installed, the armature and series-field circuits were made to take much more starting current than previously and the series field therefore overpowered the shunt field, causing the motor to run in the opposite direction while starting. The motor was probably stopped at once and the whole series field and armature circuit reversed outside the motor in an effort to reverse the armature circuit. This reversal would naturally not change the direction of the rotation as the series field still established field flux in the same relation to the armature flux as before. Then the shunt field was reversed with no better results. The shunt field was weak, compared to the series field, and the last change merely brought it in the same direction as the series field. I would suggest that the connections to the starting box be carefully checked and the motor tested for grounds and other defects; next that the shunt and series fields be connected so as not to oppose each other.

Then if the motor still runs in the wrong direction, it should be reversed by reversing the leads at the brushes. W. E. PAULSEN.
Des Moines, Iowa.

Locating Trouble in Wiring Circuit—I would appreciate suggestions from readers on the best scheme for testing B X wiring circuits for troubles such as short circuits and grounds, which does not require taking out switches and receptacles or dropping of canopies of lighting fixtures.
Brooklyn, N. Y. H. F.

Concerning the query by H. F. in the April issue of INDUSTRIAL ENGINEER, regarding the testing of wiring circuits to locate trouble, I believe that the accompanying diagram will show clearly a good method of procedure. With the lamps taken out and the fuses removed from the cutout a ring obtained when either cutout terminal is touched with one lead of the test set, while the other lead is grounded, indicates that there is a ground on that side of the circuit.



How to test wiring for grounds, shorts and open circuits.

This condition is shown in *A*. With the fuses and lamps removed, a ring obtained with the test set across the cut out terminals, as in *B*, indicates that there is a short circuit between the circuit wires. In case of an open circuit somewhere in the system, with the service connected and fuses and lamps in place the lamps on the supply side of the open circuit will be lighted. To test for an open circuit when the power supply is not connected, connect the test set across the cutout terminals, after the fuses and lamps have been removed. Beginning with the outlet closest to the cutout, short each one at the socket with a screw driver. Ringing of the test set will indicate continuity of circuit up to the outlet which is being shorted. Failure to obtain a ring, when an outlet is shorted, indicates an open circuit between this outlet and the last one from which a ring was obtained. JOHN B. RAKOSKE.
Detroit, Mich.

* * * *

In answer to H. F.'s question in the April issue of INDUSTRIAL ENGINEER, on locating trouble in wiring circuits, I suggest the following procedure: Set in the off position all switches and sockets on the circuit in which there is trouble, with the exception of the circuit switch in the distribution cabinet, (if there is one). This switch must be closed. If one plug fuse is blown, replace it with a 25- or 40-watt lamp. If the lamp lights up and you are sure that all outlets on the circuit are turned off, you either have a short or a ground. If removing the plug fuse from the circuit puts the test lamp out, you have a short circuit; if the lamp remains burning you have a ground. To locate a ground, find the center of the circuit by counting the outlets. Then open the center outlet in the circuit and examine the splices for a bare spot. If there is none, test for the live side to ground and open the live wire. If the test lamp goes out the ground is back of the open circuit; if the lamp remains lighted, the ground is ahead of the open circuit. This method of testing should be followed out until the ground is located.

To find a short circuit, the procedure described above should be followed with the exception that both the lamp and the fuse plug must be in the circuit. On a trouble job, where the lines are dead, a magneto or a bell and dry cells can be used. JOSEPH B. HUMPLEY.
Blatz Brewing Company,
Milwaukee, Wis.

* * * *

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out; namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting devices.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?
New York, N. Y. M. K.

I noticed in the July issue of INDUSTRIAL ENGINEER an answer to a question asked by M. K., in the February issue. For M. K.'s benefit I may say that I have had quite a lot of experience with various makes of

cranes, ranging from 5- to 150-tons capacity, and am glad to give him the benefit of this experience. On one occasion I had trouble similar to that described by M. K. with a 15-ton a. c. crane. Sparking was caused by the wires being drawn too tight, which is not necessary on small-tonnage cranes using small gage wire if sufficient space is available. However, we did not have much space between the shoes; so we rigged up another trolley arm on the outside of the bridge, large enough to take all wires with lots of room between. I am of the opinion that bored shoes such as are supplied by the Niles Co. for trolley service are the most efficient, but for main collectors I prefer wheels, small in diameter but with a wide groove. If the crane is located in a foundry or other dusty place it should be blown off weekly, if possible, and a very small amount of vaseline or good quality grease applied to the collecting devices.

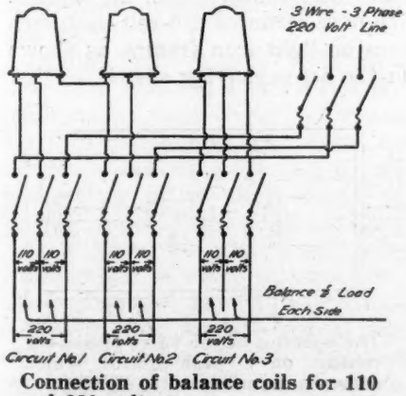
LACHLAN A. MCEWAN.
Montreal, Canada.

* * * *

How to Secure 110- and 220- Volt Service from 220-Volt Generator—We have a 7.5 kva., 3-phase, 220-volt, 60-cycle self-excited a. c. generator that we desire to use at night for lighting the boiler and turbine room and some residences across the street. I would like to have some reader tell me what transformer connections I can use to obtain 110 or 220 volts on the secondary side, so as to balance the load on all three phases. Would it be possible to use a balance coil with a three-wire secondary? If so, I would like to see a diagram of connections that will be most satisfactory.
Henderson, Ky. J. M.

For the information of J. M., who asked in the April issue how to connect balance coils to reduce from 220 to 110 volts, the accompanying sketch shows a method I have found very efficient and which I sincerely hope will help J. M. with his little problem. The coils shown in the sketch are manufactured by the American Transformer Company, of Newark, New Jersey, but I am sure that J. M. can purchase, from any manufacturer of his preference, coils to meet his requirements. With all praise for INDUSTRIAL ENGINEER, best regards to Practical Pete, and more power to him in his good work.

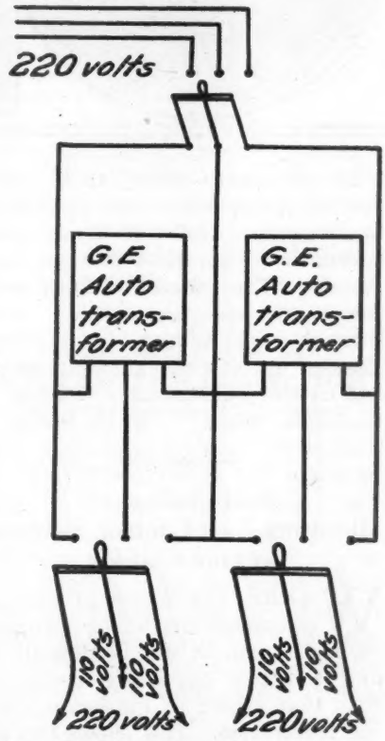
E. H. SCHRIVER.
Assistant Chief Electrician,
Irvington Smelting & Refining Works,
Irvington, N. J.



Connection of balance coils for 110 and 220 volts.

* * * *

J. M. asks, in the April issue of INDUSTRIAL ENGINEER, how he can secure 110- and 220-volt service from a 220-volt, 3-phase generator. The accompanying diagram shows how two General Electric auto-transformers can be connected so as to give him the service he desires.



Two G. E. auto-transformers connected to give 110 or 220 volts from 220-volt service.

Paterson, N. J. K. MANTEI.

* * * *

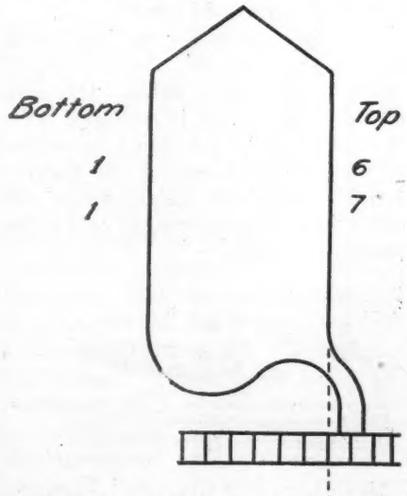
Rewinding Desk Fans—We have to rewind 16-in. desk fans of Westinghouse and Colonial make, and I would appreciate it if some of the readers will answer the following questions: How many turns and what size wire should I use for the armature coils? What is the coil pitch? There are twelve slots and twelve bars in the Westinghouse fans and fourteen in the Colonial. When the armature is mounted in the winding machine should the upper end be turned toward the operator or away from him when winding? Should the leads be brought out on the side nearest to the operator, or on the opposite side? What is the pitch of the commutator leads and does it make any difference whether I swing them to the right or to the left? This is a lap winding, and there is more wire in the last coil than in the first coil, assuming the same number of turns on all coils. Will this cause sparking at the brushes?
St. Louis, Mo. W. G. W.

In reply to the question by W. G. W. on rewinding fan motor armatures in the May issue of INDUSTRIAL ENGINEER:

(1) I do not have any winding data on these as we have found that it is cheaper to carry a stock of new armatures rather than to rewind those which are burned out. (2) The coil pitch for the 12-slot loop winding is 1 and 6, and for the 14-slot loop winding it is 1 and 7. (3) It is immaterial which way the coils are started, or in which direction the coils are wound so long as they are all wound alike. (4) It makes no difference on which side the leads are brought out, providing they are all brought out alike and on the commutator end of the armature. (5) These armatures are generally connected straight out as shown in the diagram. The leads are thrown one bar away from the line out from the top slot, the throw being away from the center of the coil. (6) With small, hand-wound armatures, loop windings, each coil has a different resistance due to each succeeding coil being larger. This has no effect on the electrical operation, but causes a mechanical unbalance.

All of the above points are mentioned in the two articles "Winding Small Armatures" that appear in the January and February, 1922, issues of INDUSTRIAL ENGINEER.

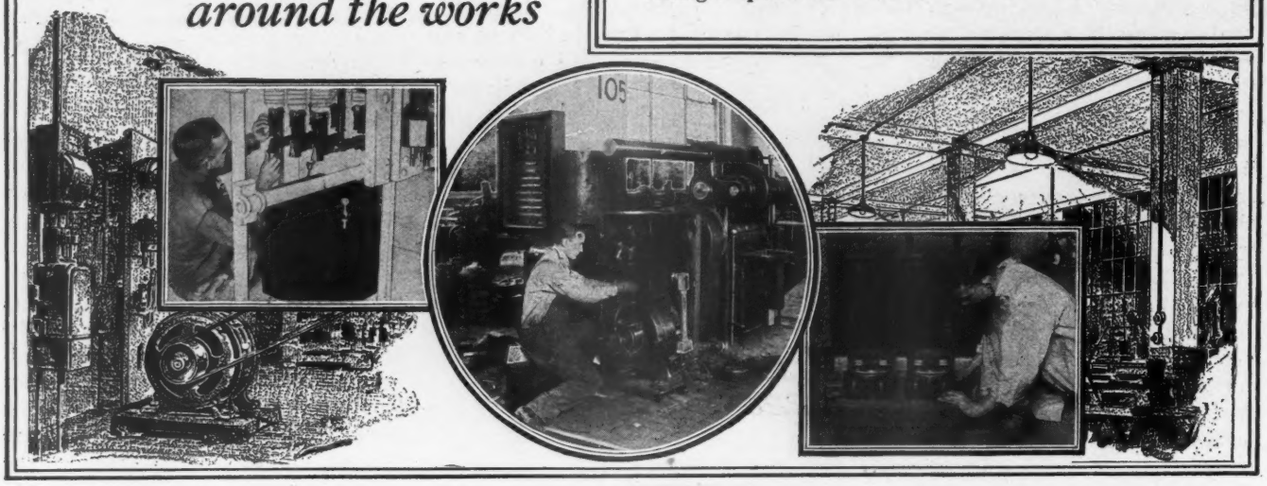
Detroit, Mich. A. C. ROE.



Lead throw for fan motor armatures.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

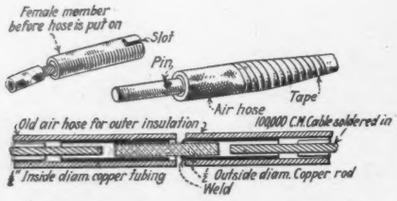


Convenient and Simple Bayonet-Type Connector for Welding Leads

A SIMPLE, quick-action connector for arc-welding leads which has been giving satisfaction for about two years in a large shipyard is shown in the accompanying drawing. It is easily handled, carries the current without overheating and will stand a large amount of abuse.

The connector is essentially a simple bayonet-type joint made from ½-in. inside diameter copper tubing into which a piece of ½-in. *outside* diameter copper rod (or tubing) is thrust and locked by a one-eighth turn. The contact area is about 2 in. long. Short pieces of copper tubing and old ⅝-in. air hose sufficient to make several dozen connectors were fished out of various scrap piles and made up at odd times.

It is the custom for each welder to have a short length, about 6 ft., of extra-flexible small cable. One end of this short cable is equipped with the male half of a bayonet connector to plug into the end of the regular 100,000 circ. mil. cable, while the other end is arranged to carry the electrode holder.



This single-conductor connector for welding leads is rugged and quickly detachable.

In the yard where these connectors are used it is not uncommon to see as much as 700 ft. of cable between the motor-generator set and the arc. The connectors have paid for themselves many times over through time saved in moving, clearing up tangles, extending leads, and cutting out damaged sections.

Bremerton, Wash. R. H. DAVIS.

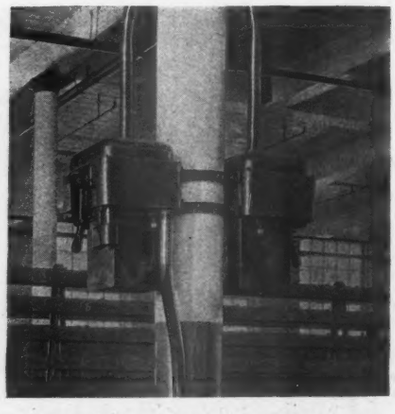
Neat Method of Mounting Two Control Switches on One Column

WHERE two pieces of control equipment are to be mounted on one column, it will be difficult to find a better appearing mounting than that shown in the accompanying illustration. This shows two oil switches used for the control of motors in a southern textile mill. Four iron straps are employed to hold the switches. Each of these straps is bent to conform to the shape of the column, and makes about one-sixth of a turn around the column. The straps are made secure on the column by means of lag bolts and the switches are bolted on to the straps with their backs to the column as shown.

The conduits running upward from the switches to the motors pass through holes in the covers. These covers may be slipped upward on the conduits if it is necessary to have access to the inside of the switch in order to inspect it or change connections.

R. S. HUNTINGTON.

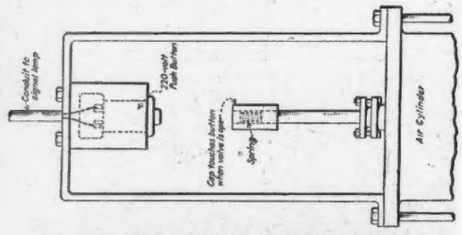
Greenville, S. C.



The two oil switches are bolted to iron straps which are fastened to the column.

Lamp Indicator Shows Which Air-Operated Valve on Tank Has Opened

THE WRITER has worked out a scheme to show at a distance when air-operated valves, which are used on the measuring tanks in the American Beet Sugar Company's plant at Oxnard, Calif., are opened. We have mounted 220-volt push buttons on light iron frames, as shown in the accompanying sketch, so that



The opening of the valve closes the contact on a push button which causes a signal lamp to light.

they will be operated when the pistons of the valves are in the open position. On the end of each piston is placed a small iron cap with a spring inside so that the pressure on the push button will not be too great.

The circuit from each button goes to a corresponding lamp, behind a glass panel, which is numbered according to the number of the tank and so identifies the valve which has opened.

W. W. PEASGOOD.
Chief Electrician,
American Beet Sugar Co.,
Oxnard, Calif.

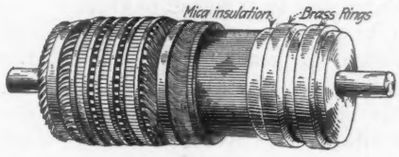
Easy Method of Obtaining Alternating Current from D. C. Machine

IT OFTEN happens that alternating current is required for some experimental work or testing when only direct current is available and the cost of a small alternating-current generator to be driven from a direct-current motor would be too high to warrant its use. Such a problem can quite often be solved at little expense by simply fixing collecting rings on the commutator of some direct-current motor or generator that is available, as indicated in the accompanying drawing.

If the machine to be used is to run as a motor, the commutator should be long enough to allow room for some of the regular brushes to remain on it to drive the machine as a motor, in addition to the room required for the collector rings. The machine must have a range of speed to cover the frequency desired. This can easily be figured, as the r.p.m. equals (60 times the frequency desired) divided by (half the number of poles in the machine). This means that a two-pole machine running at 3,600 r.p.m. will give 60 cycles, as: $(60\times60) \div (2\div2) = 3{,}600$. A four-pole machine must run at 1,800 r.p.m. to give 60 cycles, because: $(60 \times 60) \div (4 \div 2) = 1{,}800$. Lower frequencies require proportionately less speed.

Insulate with mica or other good insulating material a portion of the commutator wide enough for the rings to be mounted on. Force on the rings, shrinking them on if possible, after which they should be turned smooth and round. Each ring is then connected to one commutator bar on a two-pole machine, two commutator bars directly opposite each other for a four-pole machine, and so on, or 360 electrical deg. apart. For single phase, which requires two rings, the second ring is connected to commutator bars 180 electrical deg. from those of the first ring. For three phases the connections of each ring are 120 electrical deg. apart.

The rings are best made of brass and the connections to the commutator bars can be made with small set screws that are set down into the rings and pierce through the insulation onto the different commutator bars. The effective alternating voltage obtained is 0.707 times the direct-current voltage.



Alternating current may be obtained from collector rings mounted on, but insulated from, the commutator and connected to the proper bars, as explained in the text.

PHILIP G. BERNHOLZ.
East Orange, N. J.

Additional Steps in Making Endless Leather Belts for Transmission Purposes

IN THE June issue of INDUSTRIAL ENGINEER, on page 309, appeared some information on "Making a Belt Scraper," one of the most useful tools for a belt man. Also in the July issue, on page 365 appeared an item on "Making Laps for Cemented Endless Leather Belts for Industrial Purposes." In both instances the information was based on the experience of The Leather Belting Exchange, an association of leather belt manufacturers. The present item is based on a third contribution containing additional suggestions on the preparation of the belt and its lap for cementing.

Belts which are to be made endless may be divided into three classes:

(1) Those which have been endless, and which it is desired to shorten. (2) Those which have been running with a laced or metal fastened joint. (3) New belts which have not yet been placed upon the pulleys.

When deciding how the work is to be done these again divide themselves into two classes: (a) Those which are small enough to be thrown off the pulley and taken to a nearby bench and, (b), those which, because of their size, must be worked upon on the pulleys.

After a belt has been running endless, but has stretched a little, so that the tension is reduced, it becomes desirable to shorten it. If it is a narrow belt, which may easily be thrown on the pulley after splicing, it is first necessary to determine how much shorter the belt must be. When this is decided, find the joint which was made when the belt was last put on, or a joint which is opening, and, with the point of the screwdriver, carefully open it, by running the screw-driver under the point of the lap and working it towards the heel, as shown at *A* in the accompanying illustration, at the same time taking care not to tear the leather.

If it is a double belt each ply of leather may have its own lap, or if it is a narrow belt it may have such a lap as is used on a single belt. Remove the narrow belt to the bench; inspect carefully to see from which end it is most desirable to cut, in its relation to any other joints in the belt, and then bring the end on which it is decided to work nearly to the end of the bench; clamp the belt to the bench with bench clamps, as shown at *B*, and proceed to cut back the laps the desired distance.

When it is desired to substitute an endless joint for a laced or hooked joint the procedure is a little different. If the belt is loose enough on the pulleys so that it can be shortened the length required to make the endless joint, the process consists in removing the belt to the bench as before, and making the necessary lap. If it is a single leather belt, or if it is a narrow double, say under 6 in., an ordinary single lap may be used, as illustrated. This lap should be from 4 in. to 6 in. long, according to the width. The process then may be completed as described. If the belt is an old one, and the surface of the lap when made appears to be greasy, it should be cleaned with gasoline before attempting to cement it.

Where the belt is not long enough to provide from its stretch sufficient material for the lap, it becomes necessary to prepare a piece to set into the belt. If it is a single belt, this may be a very short piece with a lap on each end, as illustrated at *C*; then laps must be cut upon the old belt to fit this piece and the cementing process applied as described. Where it is a narrow double belt, the

piece inserted may be made in exactly the same way. For a wider double belt the piece should be arranged so that it provides a separate joint for each of the two plies of the double belt, with these two joints "broken" so that they do not come together. This type of joint is illustrated at *D*. The ends of the belt then may be fitted to this insert.

With wider belts or those which cannot be carried conveniently to the belt bench it is necessary to work with belt clamps. If an old belt is to be shortened, first find the point on the belt at which the joint has been made, and bring the belt around to a place between the two pulleys where it may be most convenient to work. Then put on the clamps, with jaws conveniently spaced on each side of the joint.

In putting on belts with clamps the first requisite is to see that the middle line of the width of the belt corresponds exactly with the middle line of the distance between the centers of the rods of the clamps.

The next point, a most imperative one, is that each pair of jaws of the clamps shall be exactly square with the edges of the belt. A little care here in drawing up evenly on the two rods will bring the two ends of the belt square and true, and will save effort and a crooked belt.

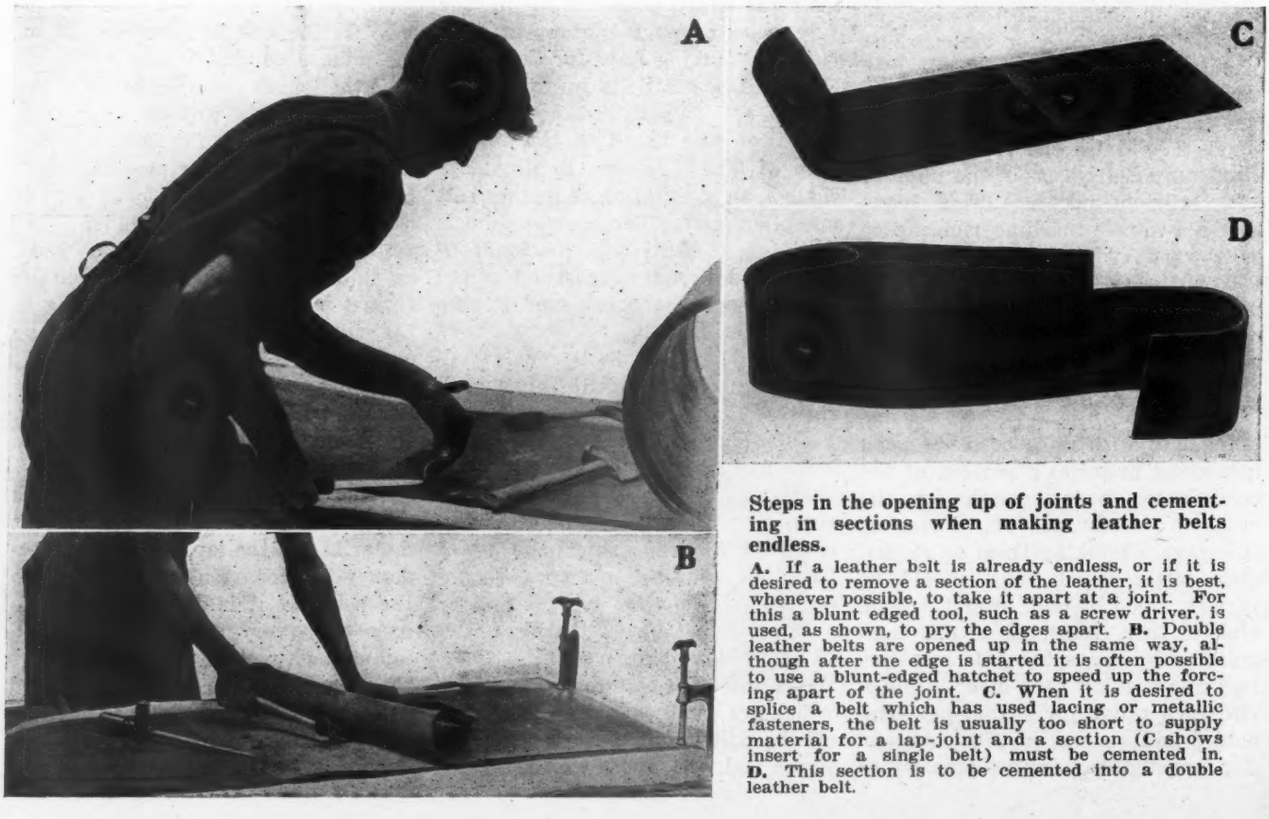
Apply enough pressure to the clamps to take the tension of the belt off the joint, and then open the joint with the screw-driver, as before, cut down the new lap on one end with the spokeshave and the scraper, scrape off all the old glue from the lap on the other end, as described on page 365 of the July issue, and proceed as before. This work can be best done on a clamp board, which fits between the side rods of the clamp and is attached to them.

In putting on new belts the laps should be made at the bench, the belt drawn over the pulleys and then the clamps adjusted as above described. If a belt is to be purchased for that installation, give the belt maker the exact length around the pulleys, stating whether it has been measured with a steel tape, a cotton tape, a wire, or a string, and let him make the allowances, and tell him to make it "endless-open laps." Measurements made with other than steel tape are not reliable. It then will come to hand ready to be placed around the pulleys and cemented.

In the case of new belts which it is desired to place on the pulleys endless, the first thing is to get the proper length of the belt. It is usual to estimate that the belt should be one-eighth of an inch to the foot, or 1 per cent less than the actual steel tape measure around the pulleys, and for small belts, which are to be thrown on the pulleys, without the use of clamps, this will be found to be sufficiently accurate. For those belts which are to be put on with clamps, or where it is necessary that the belt shall be tight to produce tension, this allowance may be increased slightly, but not much. For single belts, to this length must be added the length of one lap. The belt may be cut to this total length, and the laps prepared and cemented as described in the previous item.

For double belts, the plies should be opened for a little distance from the ends of the belts. This distance must vary with the width of the belt, and consequently the length of the lap desired, as well as with any other joints which may be near the ends. It may be desirable to make it long enough on one side of the belt or the other to include an existing lap, so that two of them shall not come close together on the same side of the belt. This distance must be long enough so that each lap will have a piece of whole leather on the opposite side. When this distance is determined one side of one end and the opposite side of the other end must be cut back the proper distance, as shown at *D*. Then the laps may be made on both of the two sides, on both of the two ends, as described.

Usually new belts can be prepared best at the bench. If it is a belt of



Steps in the opening up of joints and cementing in sections when making leather belts endless.

A. If a leather belt is already endless, or if it is desired to remove a section of the leather, it is best, whenever possible, to take it apart at a joint. For this a blunt edged tool, such as a screw driver, is used, as shown, to pry the edges apart. **B.** Double leather belts are opened up in the same way, although after the edge is started it is often possible to use a blunt-edged hatchet to speed up the forcing apart of the joint. **C.** When it is desired to splice a belt which has used lacing or metallic fasteners, the belt is usually too short to supply material for a lap-joint and a section (**C** shows insert for a single belt) must be cemented in. **D.** This section is to be cemented into a double leather belt.

any size it may take some effort to bring the two ends close enough to slip the clamp rods into place. Clamps for very wide belts usually are made with a heavy screw-eye bolt in one of each pair of blocks, so that a chain hoist, or a block and tackle may be used to bring the ends of the belt together. With a new belt it is necessary to pull it up to a point where the laps fit perfectly. If proper allowances have not been made and the belt is too long the lap must be scraped back to shorten it, unless a big error has been made.

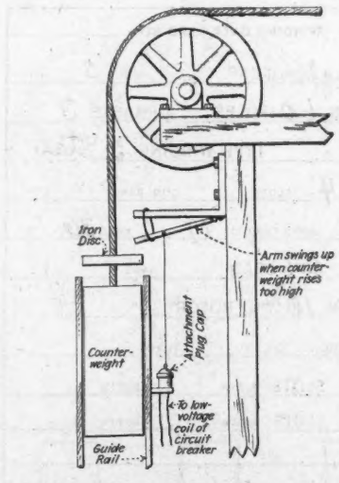
It is generally agreed among belting men that single belts should be put on so that they have an initial tension, before starting, of 72 lb. per in. of width, and double belts in proportion. Ordinarily, there is at hand no method of measuring this tension, and it becomes a question of judgment of the operator which he can get by watching the performance of his belts after they have been running.

LOUIS W. ARNY.

Secretary,
The Leather Belting Exchange,
Philadelphia, Pa.

Safeguard to Keep a Hoist from Overrunning by Stopping Motor

BECAUSE the limit switch from the lime-kiln hoist in our plant has failed to operate several times an additional safeguard has been installed. This consists of an attachment plug having a cap whose terminals are short circuited. The circuit from the low-voltage-release coil of the hoist circuit breaker is run through this attachment plug and the short-circuited cap. As shown in the accompanying drawing the cap is so arranged that if the counter-weight should travel too high in its path it will strike an arm which is attached by a string to this cap. This will throw the cap out of the plug and thus open the circuit to the low-voltage-release coil, which will stop the hoist motor.

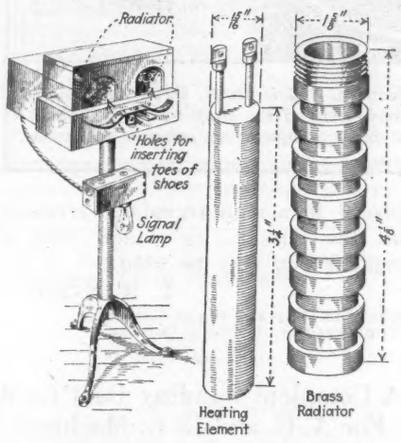


When the counterweight travels too high the cap of the plug is pulled out. This opens the circuit to the low-voltage-release coil.

Chief Electrician, W. W. PEASGOOD.
American Beet Sugar Co.,
Oxnard, Calif.

How to Make an Electrically-Heated Tank for Vaporizing Water

WATER can be vaporized for humidifying or manufacturing purposes in easily made devices similar in general design to the one which is described in this article and used for steaming the box toes of shoes. For this service a tank of 2 qt. capacity requires 750 watts and when so equipped the hourly evaporation will be 1 qt. of water when its initial temperature is 60 deg. F.



Details of an electric vaporizer which is used for steaming shoes.

The box toe of a shoe is placed in each of the semi-circular openings. Radiators containing heating elements may be seen through the openings. A separate detail of the radiators and 150-watt heating element is also shown. The rectangular cover for catching the steam is made of sheet copper. The lamp shows whether or not the current is on.

The water container consists of an open-top, cast-iron box 4½ in. wide and 3½ in. deep and as long as required. Screwed into one side of this box and projecting into it are special cast-brass radiators, as shown in the illustration. These are spaced 1⅛ in. apart. A 150-watt heating element 15/16 in. in diameter by 3¼ in. long is then placed in a 1-in. hole drilled into one end of each radiator.

The radiators are automatically kept submerged by means of a float and needle-point valve in a water reservoir which is capable of supplying the water to a number of vaporizers. The water container is insulated with a covering of asbestos over the bottom, sides and ends. The container is then placed in a larger sheet metal box and mounted on a pedestal of suitable height. The outer box is large enough to protect the connections at the back of the heating elements. Two copper busbars mounted on porcelain insulators are run the entire length of the water box and the leads from each heating element are connected to the buses.

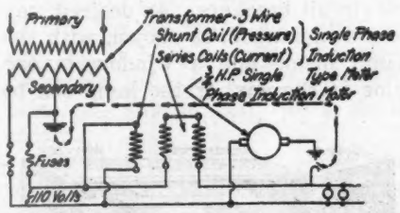
ALBERT KOCHS.

Chief Engineer,
Hamilton Brown Shoe Co.,
St. Louis, Mo.

Motor Lead Grounded to Conduit Shunts Out a Meter

USUALLY an accident to the wiring or equipment means a loss to the owner but a peculiar condition which was not detected for some time actually saved us money, although it was at the expense of the power company. As will be seen from the accompanying illustration, we have a ¾-hp. single-phase induction motor and a lighting circuit which are connected through the same meter. One of the leads to the motor had broken off at a kink inside the conduit. One end of this lead had, through constant vibration, come in contact with the grounded conduit and the consequent arcing had practically welded the wire and conduit together. It will be seen that when the switch was closed the motor operated but the meter did not register as one side of the circuit was made between the motor and the transformer through the ground, thus causing an unintentional theft of power.

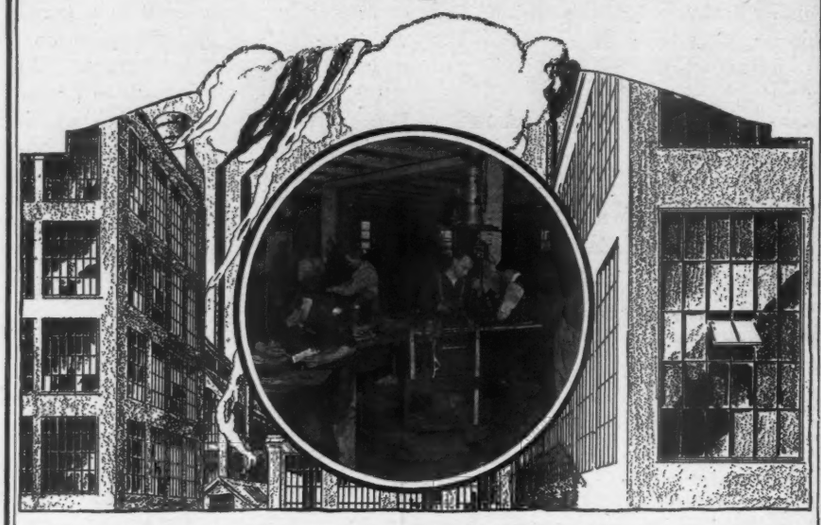
Leads *A* and *C* should be connected to *D*, and *B* should be connected to *E* in order to prevent loss of energy through a ground return and still maintain the proper direction of rotation of the meter disc.



When a motor lead became grounded to the conduit current flowed from the conduit to the grounded transformer, preventing the meter from registering.

Honolulu, Hawaii. ALLAN H. CUNHA.

In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

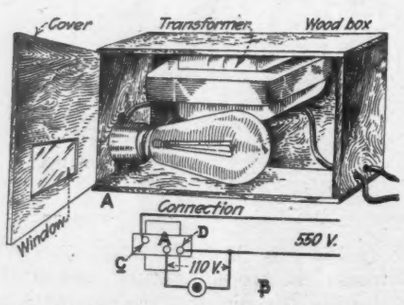
Easily Made and Compact Testing Lamp for Use on 550-Volt A. C. Circuits

WHEN making tests on 550-volt alternating current circuits, instead of using the customary five lamps mounted in series on a board we use a small transformer and one lamp, as shown in the accompanying illustration. The advantage is that only one lamp is needed, which means that only one-fifth as many lamps need be replaced on account of breakage. This outfit is smaller and easier to carry than the five lamps in a bank, as ordinarily used.

This little testing device consists of a wooden box containing one of the small transformers used in connection with the no-voltage release on K-20 Canadian General Electric oil circuit breakers. As desired, box can be arranged, as shown, with the lamp inside and a window in one side of the box, or the lamp can be placed in a sign receptacle screwed on the outside, in which case a smaller box may be used.

J. H. SAUVE.

Reardon Pulp and Paper Company, Timiskaning, Quebec, Canada.



For testing 550-volt a.c. circuits this outfit is less cumbersome than five lamps in series.

A Complete Winding Data Card For A. C. and D. C. Machines

RECENTLY I have had occasion to collect winding data for a large number of motors of different makes and the accompanying illustration shows a motor and generator data card which I am using. It has been found very convenient for this purpose. As will be seen, this card, which measures 6 in. by 4 in., can be used for compiling winding data for either a. c. or d. c. machines, and when properly filled out gives about all the data that would be required.

I am interested in cards and card systems for the collection of information of this nature and I am showing this card not because I think it is the best that could be worked out, but have made this contribution in the hope that other workers in this line will show what they have found best suited to their needs. In this way, we can all profit by the experience of the other fellow and a better data card will be the result. Accurate and complete winding data is such an important part of the motor repairman's equipment that I feel that the problem of keeping the data in such form that it can easily be found when wanted is worth a good deal of attention.

V. G. WEBER.

Portland, Ore.

What form of card have you devised for collecting winding data for motors of various makes and types?

OREGON INSTITUTE OF TECHNOLOGY — WINDING DATA CARD NO. _____

MACHINE — MAKE Westinghouse — CAP.: — KW. 5 — H. P.

VOLTS 220 — AMPS. 12.7 — SPEED 1700 — CYCLES 60 — POLES — PHASES 3

CLASS — TYPE CCF — FORM — TYPE WINDING 2 Star

NO: SPEC. — SERIAL — COILS 24 — SLOTS — COM. BARS

WIRE: NO 16 — INSUL — IN HAND 2 — TURNS PER COIL 17 — LBS. 36

PITCH: FRONT — BACK 1-12 — COM. — COM. LEAD — BARS

STYLE COIL — CEN. to CEN. COIL FORM 10 3/4 — ROTOR

START COILS: NO — SIZE WIRE — INSUL. — TURNS

ARM IRON: LENGTH 2 — DIAM. 8 3/4 — DEPTH — SLOTS: WIDTH — DEPTH

ROTOR IRON: LENGTH — DIAM — DEPTH — SLOTS: WIDTH — DEPTH

REMARKS:

NOTE—USE BACK OF CARD FOR ADDITIONAL DETAILS ON INSULATION AND COIL FORMS

Winding Stator of Single-Phase Compensated Series Motor

A WINDING for a single-phase, compensated series motor which we put in a stator some time ago should be of interest to readers of INDUSTRIAL ENGINEER. This method of winding allowed the use of form-wound coils all of the same dimensions but some of the coils had twice as many turns as the others. Another unusual feature of the stator was that some of the teeth were wider than others.

The stator had thirty slots and

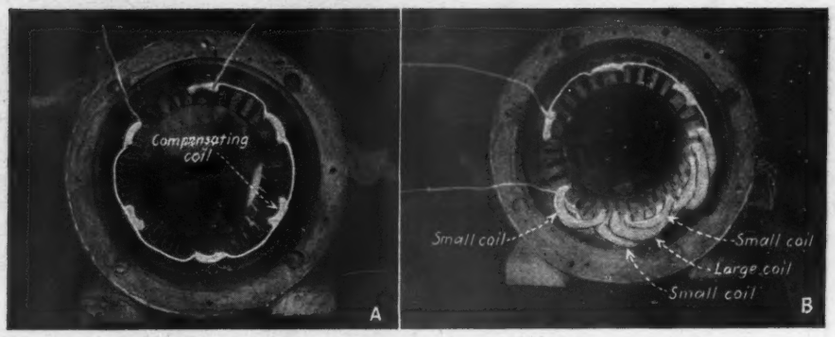


Fig. 1—Compensating and main winding of series, single-phase stator.

At A the compensating winding is shown in place. The six compensating coils are placed around the six large teeth. At B is shown part of the main winding. This consists of eighteen coils, six of the coils being twice as large as the remaining coils. Note how the upper side of the first main coil is held in place during winding by several wedges placed over it in the slot.

twenty-four coils. There were eighteen main coils and six compensating coils. Every fifth tooth had twice the area of the others, as shown in Fig. 1. The compensating coils were wound around these six large teeth. The coils were wound by hand, every alternate coil being wound in an opposite direction, as shown in *E* of Fig 2. The wire was not cut at the end of each coil but was carried over to the next coil, thus doing away with soldered connections. The first compensating coil started in slot No. 1 and finished in slot No. 2. Then the second coil started in slot No. 6 and finished in No. 7. This was repeated around every large tooth, as in *A* of Fig. 1.

Fig. 1, *B*, shows part of the main winding in place. This winding consisted of eighteen coils and six of the coils had twice as many turns per coil as the remaining twelve coils. This winding was a combination of a winding with two slots per coil (single-layer) and a winding with one slot per coil (double-layer). A study of *B* in Fig. 1 will show that each coil with the larger number of turns completely fills two slots. Each small coil is put in so that one side is in the same slot as one-half of a compensating coil; the other side overlaps another small coil. These small coils in turn are made to overlap each other in every sixth slot.

Fig. 2 gives the steps in putting on the main winding. The compensating coils are indicated by the short loops inside the small circle. The first main coil to be put in is a small coil. It is placed in slots No. 1 and No. 4. Slot No. 1 contains also one-half of a compensating coil. These two coil halves completely fill slot No. 1. The second main coil is a large coil and is put in slots No. 30 and No. 3, completely filling these slots. The third main coil (a small one) is put in slots No. 29 and No. 2. Slot No. 2 contains one-half of a compensating coil; therefore it is filled when the third main coil has been put in.

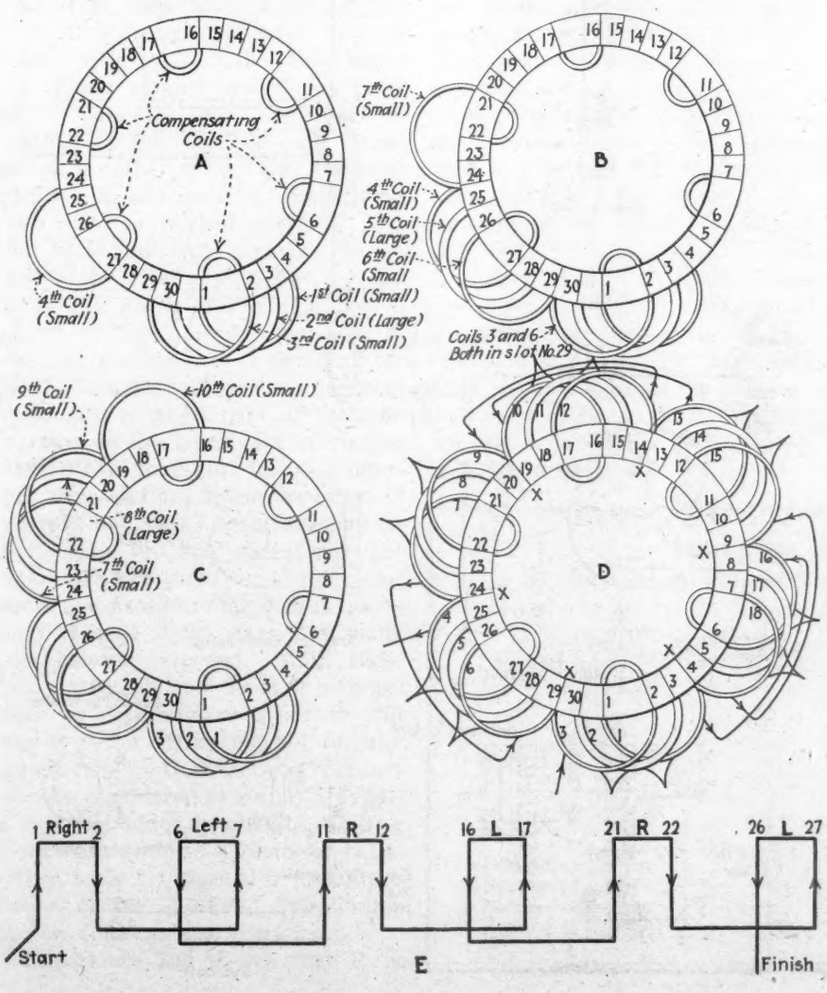
The fourth main coil is put in slots No. 24 and No. 27. This is a small coil and fills up slot No. 27 which already contains one side of a compensating coil.

In *B* of Fig. 2 is a continuation of the winding. The fifth coil is a large one and is put in slots No. 25 and No. 28 working in the opposite direction to the first group. Coil No. 6 is put in slots No. 26 and No. 29. Slot 26 also contains one side of a compensating coil. Slot 29 already holds one side of coil No. 3; therefore coils No. 3 and No. 6 overlap each other in slot No. 29 and fill this slot.

Coil No. 7 is started in slots No. 21 and No. 24 filling both slots, as slot No. 21 holds one side of a compensating coil and slot No. 24 contains one side of coil No. 4, as is shown.

The next drawing, *C*, shows the third group in place and the start of the fourth pole group. At *D* are seen all the coils in place with the groups connected. Note that coil No. 18 overlaps coil No. 1 in slot No. 4; also that twelve small coils fill eighteen slots. The winding is so distributed that these small coils overlap each other at six points and in twelve other slots they are put on top of the compensating coils. The six large coils fill the twelve slots.

Fig. 2—Steps in winding single-phase stator of series motor.



Bill of Material for Armature Winding Rack

Part No. See Drawing	Description	Number Required	Part No. See Drawing	Description	Number Required
1	Armature shaft roller.	4	14	1-in. x 13-in. pipe nipple	4
2	Armature shaft roller casting	2	15	1¼-in. x 18-in. pipe..	1
3	Roller pin	4	16	1¼-in. x 13-in. iron plug. Turn to fit inside 1¼-in. pipe....	1
4	Washer for roller pin No. 3	4	17	½-in. x 1-in. set screw	1
5	Clamp for wire-tension device rod	2	18	1-in. x 10¾-in. nipple	4
6	"U"-bolt for clamp No. 5	2	19	Standard 1-in. pipe union	2
7	1¼-in. x 12-in. pipe-support for casting No. 2	2	20	Standard 1-in. tee....	4
8	⅜-in. x 36-in. pipe to carry wire-tension device	1	21	Standard 1-in. pipe plug. See No. 22....	4
9	Standard 1¼-in. tee..	2	22	Caster plate, dimensions determined by type of caster. Punch and weld to head of plug No. 21.	4
10	Standard 1¼-in. close nipple	2	23	Swivel caster	4
11	Standard 1-in. tee with 1¼-in. outlet to be tapped for ⅜-in. eye bolt as shown.....	2	24	Standard $\frac{3}{16}$-in. x ½-in. flat-head set screw.	4
12	Standard 1-in. close nipple	4	25	⅜-in. x 6-in. eye bolt to carry ⅜-in. pipe for wire reel.....	2
13	Standard 1-in. 45-deg. ell	8	26	⅜-in. x 36-in. pipe to carry wire reel.....	1

The main coils were all wound on the same mold, the only difference being in the number of turns per coil. In the original winding the three coils per group were wound on what is known as a gang mold. This is a mold with three center pieces and with thin barriers between. The three coils are wound without cutting the wire. From three coils only two leads are brought out, start and finish, which does away with twelve stub connections. However, when only one motor is to be rewound the extra time required to make a gang mold is much greater than that required to stub up the groups.

The armature of the motor was wound similar to any standard direct-current wave-wound armature.

Detroit, Michigan. A. C. ROE.

Strong and Handy Armature-Winding Rack Made From Pipe and Fittings

AN ARMATURE winding and banding rack which the writer built from standard pipe, fittings and nipples, is shown in the accompanying drawing. This rack was made from 1-in. and 1¼-in. pipe. The armature shaft is carried on two pairs of rollers, each roller being 3¼ in. in diameter. Four casters are inserted in the base of the rack so that it can be moved about readily. At the lower part of the rack there is a ⅜-in. pipe which hangs in two eye-bolts to support the wire reels. In the upper part is another ⅜-in. pipe for supporting the device for putting tension upon the wire in case the armature is being banded.

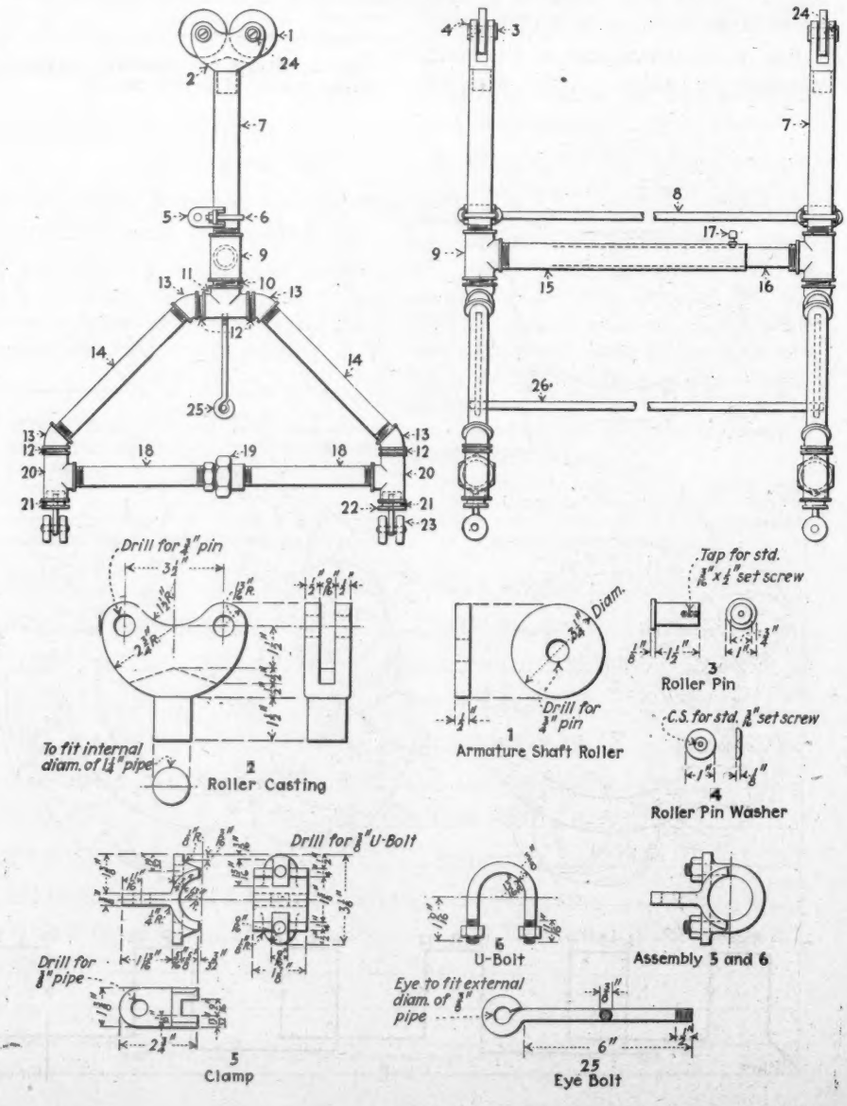
In the construction of this rack there are a few castings and other parts which have to be made. The castings consist of two pivoted bearings for holding the rollers and two clamps for holding the pipe which supports the tension device. Besides this, there are roller pins, the two eye-bolts for supporting the pipe which holds the wire reel and two U-bolts.

It is advisable to make the rollers of copper, brass or fiber so that they will not scratch the shaft. These rollers are 3¼ in. in diameter by ½ in. thick and are drilled for a ¾-in. pin.

A complete list of the bill of material is shown in the accompanying table and the drawings give the details of the special parts which have to be made, with two views of the assembled rack. JOHN W. HOBART.

New York, Ontario & Western R. R., Middletown, N. Y.

This armature rack was made almost entirely from standard pipe and pipe fittings.


Drill for ¾" pin
To fit internal diam. of 1¼" pipe
2 Roller Casting
1 Armature Shaft Roller
Tap for std. ⅜" x ½" set screw
3 Roller Pin
C.S. for std. ⅜" set screw
4 Roller Pin Washer
Drill for ⅜" U-Bolt
Drill for ⅜" pipe
5 Clamp
6 U-Bolt
Assembly 5 and 6
Eye to fit external diam. of ⅜" pipe
25 Eye Bolt

Handling Materials

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

A Few Examples of Applications of Lifting Magnets in Industrial Works Which Suggest Ideas Usable in Other Plants

IN DETERMINING whether a lifting magnet will be economical and if so, how much could be paid for it, a rough estimate may be based upon the fact that $100 worth of lifting magnet will do as much work handling iron and steel as could be expected from one strong man. In other words, a $1,600 magnet can do the work of sixteen men, and may be worked overtime with but little additional expense. In addition the total cost of owning, upkeep and power for a magnet is about 10 cents per day per $100 of cost, or one-tenth of 1 per cent per day. On a $1,600 magnet this would approximate $1.60 per day in comparison to the labor cost of sixteen men. This total cost includes interest, depreciation, upkeep and cost of current but does not include any labor costs for the operator. The operator is required for the crane or hoist and no additional help is necessary because of the magnet. Usually less help is required. With these two statements as a basis, it becomes easy to determine whether it will pay to use a lifting magnet for any given job. Ordinarily a magnet may be considered as simply an additional tool added to already existing equipment such as a crane or hoist. Other tools for cranes or hoists are hooks, chains, buckets and similar devices for grabbing or lifting.

Experience has shown that it is not always necessary to handle large quantities of material before a magnet becomes economical. For example, in one of our largest industrial plants rivets are made and conveyed to a boot behind a long annealing furnace. A 10-in round magnet is automatically lowered into this boot and hoisted. When down it is energized and picks up about 25 to 40 lb. of rivets. When it reaches the top of its travel it is automatically de-energized and drops the rivets into a chute. From this they go into the annealing furnace a few at a time without piling up. This automatic operation saves the labor of a man on each turn. It is difficult to get and keep men on hot, disagreeable jobs such as this.

The use of a magnet for piling and unpiling or for loading or unloading iron and steel is probably one of the most common of its industrial applications. For example, at *A* a magnet weighing about 500 lb. handles two small steel ingots at a lift at the Sanderson plant of the Crucible Steel Company. This magnet not only reduced the amount of yard labor required but enabled the ingots to be piled closer and higher as no space need be left for chains. Also, as no chains are required, handling is much quicker and safer.

The 40-in. round magnet shown at *B*, unloads at a lift three 2,000-lb. 8-in. by 8-in. billets. This is only an occasional job, however, as the regular work of this magnet is to load a car of plate scrap each week. Although this is not a heavy task it actually saves about $35 per week or approximately the total cost of the magnet per year, and does a job otherwise hard to take care of as it was too infrequent to keep a gang of men just for this work, and so caused considerable labor turnover. The 40-in. magnet shown in *C* also handles billets in the yard of the Pittsburgh Steel Forge Company. Here it not only saves labor cost but increases the capacity of the yard by higher and closer piling. Since this photograph was made the magnet installation has been duplicated.

For handling long material which would be difficult to balance from a single magnet a spreader-beam with magnets at each end is frequently used. For example, in *D* two special rectangular magnets are shown lifting thirteen 90-lb. rails 40 ft. long, or a total weight of 15,500 lb. These magnets are two of nine used in the rail mill of the Inland Steel Company at Indiana Harbor, Ind.

Steel Pipe Handled per Lift By Two 20-in. Round Magnets (E) on Spreader Bar

No. of Pipes Per Lift	Diameter Inches	Length In Feet	Weight Each, Lb.	Total Weight
1	12	20	900	900
1	10	20	823	823
2	8	22	500	1000
2	6	22	422	844
3	5	22	326	978
4	4	22	239	956
6	3	22	168	1008
7	2½	22	128	896
4 Bundles of 3 Pipes	1½	22	60	720
4 Bundles of 3 Pipes	1¼	22	50	600
4 Bundles of 6 Pipes	1	22	37	888
4 Bundles of 12 Pipes	½	22	18.7	895

This particular magnet installation is distinctive because of its low headroom, the relatively light weight, and because of the design which eliminates any chance of the long rails working loose while being lifted. Such work as this could not be done economically in any other way.

Several pipe warehouses use magnet installations similar to that shown at *E* for unloading, reloading and for general handling of pipe into and out of the warehouse. In this particular installation two 20-in. round magnets are attached to a spreader beam and spaced about 8 ft. apart. They are used to handle a wide variety of sizes of steel pipe with an average lift of about 900 lb. What this magnet actually lifts at the Chicago warehouse of Kelly and Jones Company is shown in the accompanying table. Here it is noted that the smaller sizes of pipe are handled in bundles, instead of as individual pipes. The big advantages in this installation lie in the elimination of labor, the reduction of accidents and the doubling or trebling, or even more of an increase in the capacity of warehouse space by being able to pile closer and higher.

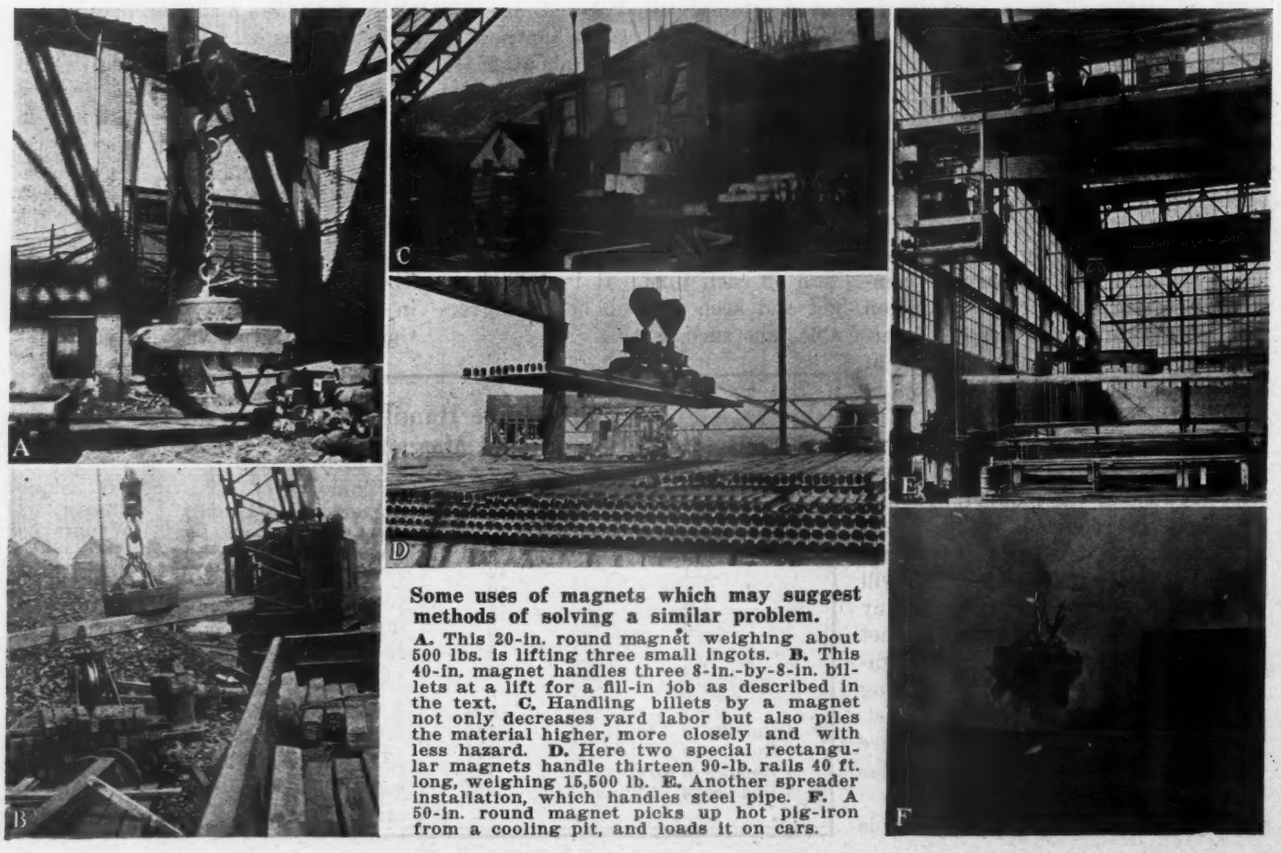
A peculiar installation of a magnet is shown in illustration *F*. Here the magnet is almost obscured by the steam rising from boiling water from which it has just lifted a load of hot pig iron. Two casting machines discharge red hot pig iron into this pit, where it is sprayed with cold water. The magnet, however, reaches down and lifts the pigs out and loads them on cars long before they have cooled. This is a job which it would be impossible to do by hand. This magnet, however, did this work for over three years. However, because the scale which forms on the pig blocked the sewer, another method of cooling and loading the pig iron was installed and the magnet has since been transferred to other work.

Another interesting application consists of a small magnet on a rotating arm mounted so that when it is in its low position the magnet is energized and touches the surface of a galvanizing trough where it picks up a load of pipe fittings. The excess spelter drains off as the arm rotates further. The current is controlled by a drum switch on the same shaft and when this magnet reaches the horizontal position current is cut off and the load of galvanized fittings is dumped into a waiting barrow. This application not only saves labor cost but eliminates a hard job which was very injurious to the workmen. In a somewhat similar application in another plant two magnets on a spreader beam pick up steel angles which have just been galvanized and lower them into a trough of water to cool and wash away any excess of the ammonium chloride flux.

Perhaps the most unusual application of any of these is that of a magnet with a special lead support which is now being built for the Trumbull Steel Company of Warren, Ohio. This is to be used solely to recover coils of strip steel which occasionally fall off the racks in the acid tanks. The acid is 6 ft. deep and it would be very difficult to get these coils out in any other way. This is an interesting use of a magnet.

These are only a few of many examples which could be given to illustrate the saving in labor or time, the reduction in accident hazard and other advantages which result from the use of a magnet in industrial works. Because of the big savings possible at low cost, it is seldom necessary to find continuous work for a magnet to make its installation economical. In one case mentioned here one job a week repaid the cost of installation. F. W. JESSOP.

The Ohio Electric & Controller Co., Cleveland, Ohio.



Some uses of magnets which may suggest methods of solving a similar problem.

A. This 20-in. round magnet weighing about 500 lbs. is lifting three small ingots. **B.** This 40-in. magnet handles three 8-in.-by-8-in. billets at a lift for a fill-in job as described in the text. **C.** Handling billets by a magnet not only decreases yard labor but also piles the material higher, more closely and with less hazard. **D.** Here two special rectangular magnets handle thirteen 90-lb. rails 40 ft. long, weighing 15,500 lb. **E.** Another spreader installation, which handles steel pipe. **F.** A 50-in. round magnet picks up hot pig-iron from a cooling pit, and loads it on cars.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Master Builders Company, Cleveland, Ohio.—A small folder describes "Quickfix," a new compound for repairing concrete floors, which, it is claimed, will produce a patch of flint-like hardness in 48 hr. It is particularly adapted to repairing aisles and runways worn by trucks or trailers in industrial plants, with but little interference with traffic. In cases of emergency patches can be laid Saturday noon and the floor will be ready for use Monday morning. It is claimed that floors can be repaired at a cost of less than 2 cents per sq. ft. for material.

The Texas Company, 17 Battery Place, New York City—The May issue of the magazine, "Lubrication," a technical publication which is devoted to the selection and use of lubricants, and distributed by The Texas Company, devotes considerable space to the lubrication of knitting and textile printing machinery. Each issue covers the lubrication of some special type of machinery.

Terminal Engineering Company, Inc., 17 West Forty-Fourth Street, New York City—Circulars describe the TEC elevating platform electric industrial trucks for urban haulage. The particular feature of these trucks is that they have a larger platform and higher wheels than the ordinary trucks. Also, this enables them to be used either within a plant or on the street for hauling some distance between buildings or plants. These trucks are 4-wheel drive and use a special platform which may be loaded separately and picked up by power and carried by the truck. A wide variety of applications is illustrated.

The Electrical Alloy Company, Morristown, N. J.—Catalog 10, Bulletin 2, describes "Calido," a nickel-chromium resistance wire for electrical heating devices and high resistance units, by means of a number of charts and tables. One page is given over to a list of the various bulletins issued by this company on special alloys.

Lewellen Manufacturing Company, Columbus, Ind.—Catalog 15 describes the Lewellen variable speed transmissions. These consist of a special belt passing over tapering pulleys the diameter of which may be varied and so change the speed ratio. These are made either in ball-bearing types for continuous or heavy operation, or in self-oiling types where operation is intermittent or occupies only a short period within the year, as in the canning industry. The illustrations show the construction and assembly as well as a description of a number of installations. Several pages of necessary engineering information and data are included.

Superior Flake Graphite Company, 76 West Monroe Street, Chicago, Ill.—A series of small folders describe the various types and uses of "Superflake" graphite for crucibles, lubrication, boiler compounds, and various other miscellaneous applications.

Jewell Belting Company, Hartford, Conn.—A four-page folder describes the use and application of Jewell liquid belt dressing to leather belts.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—Bulletin 1003-A describes the construction and operation of the Type Q brakes for use in stopping and holding rotating machinery. Probably the most general application is on cranes and other types of hoisting machinery. These brakes are made in two general styles with reference to the method of operation. For example, one style is magnetically operated while the other is mechanically operated.

(*This table is continued from page 402*)

SYMPTOM	TROUBLE	CAUSE	REMEDY
		A^{11} Insulation roasted by constant overload.	A^{11} Same as A^2.
	B Short circuit between high and low-tension windings.	*B* Any of the causes in trouble A.	*B* Same as A^2.
	C Ground between low-voltage winding and core.	*C* Lightning discharge, insulation break-down due to line surges or shifting of coils.	*C* Same as A^8.
	D Short circuit on terminal board.	*D* Moisture in oil.	*D* Remove terminal board, bake and revarnish and pass oil through a filter press.
	E Short circuit between high or low-tension bushings.	*E* Bushings broken or cracked.	*E* Replace bushings.
	F Improper division of load.	*F* Parallel operation of transformers with different characteristics.	*F* Transformers which are to be paralleled should have the same characteristics. If one bank has a high reactance and it is desired to parallel it with a bank having a low or no reactance, reactance coils should be inserted between the two banks.
	G Low-voltage windings punctured.	*G* Ground on high-voltage line of a star-delta system. A ground n such a system imposes delta voltage on the star winding, or star voltage x $\sqrt{3}$, and the bank cannot be operated.	*G* Remove ground before trying to operate. If system is properly protected the circuit breakers will open and cannot be again closed.
5 Unequal heating in bank of star-connected transformers with the neutral grounded.	Ground on one phase.	Defective insulation in transformer or ground on line due to defective insulators, dead birds, kite strings or other obstructions.	Disconnect the bank from service immediately, since a trouble of this kind short circuits the bank. Note: The insulation between the windings and core is limited to a voltage of 57.7% of the line voltage, with a star connection, and if one phase or line is grounded, the voltage between the ground and the remaining two circuits is increased to as high as full line voltage in some cases.
6 Unequal heating in bank of transformers, connected star primary, delta secondary, with grounded neutral on high-voltage side.	Ground on one of the primary phases.	Same as above	Disconnect the bank until the trouble is removed as the bank cannot be operated on open delta.
7 Voltage not the same in all phases of a three-phase bank of transformers.	*A* Ground on one phase of a bank connected star-delta.	*A* Broken insulator on line, line in contact with some obstruction leading to ground, defective insulation in transformer, bushing punctured and terminal grounded.	Cut out the bank on which the defect occurs and remedy by removing cause of ground, replace insulators, bushings or section of winding causing trouble.
	B One transformer bucking the other two.	*B* One transformer connected so that its polarity is opposite that of the others. If not cleared soon one or more of the transformers may burn out.	Change the polarity of the transformer causing the trouble. To test polarity, connect the primaries in parallel and the secondaries in parallel, with a fuse in series with the secondary windings. If transformers are of opposite polarity, the fuse will short circuit one transformer on the other and will consequently blow the fuse. If the fuse blows, interchange the leads and test until the fuse does not blow, when the polarities will be the same.
8 Voltage too low	Wrong ratio.	Leads not connected to proper taps.	Raise the taps to one higher or until voltage is correct.
9 Voltage too high.	Wrong ratio.	*A* Same as above. *B* Transformers paralleled that have different ratios.	*A* Lower taps until voltage is correct. *B* Change ratios until all transformers are same or if this cannot be done replace transformers.

Super-Safety Electric Switch Company, 1200 West One Hundred Fourth Street, Chicago, Ill.—A circular describes the "Super-Safety Switch" which is claimed to be absolutely safe, as no live parts are exposed even with the door open. Also, fuses are automatically thrown into and out of circuit with the throw of the handle, and when dead are exposed to view, which eliminates the possibility of touching live fuse terminals when it is necessary to renew a fuse. Numerous other claims of advantages of this switch are given.

Angle Steel Tool Company, Plainwell, Mich.—A folder describes a number of the various types and styles of steel stools and chairs for factory, office, and other industrial and business purposes. These are made of angle steel with hardwood seats.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill.—A folder describes and illustrates the use of Janette special motors of 1/20 to ¼ hp. on Addressograph machines.

The Robbins and Myers Company, Springfield, Ohio—Bulletin 135 gives the details of the new Type L polyphase motor which is being made in a large range of sizes. Among the many features claimed are a new method of ventilation which enables the motor parts to be constantly bathed with cool air, a higher power factor, improved starting torque, dust-proof bearings, reversible terminal box with cover removable, and a decrease in size and weight with added rigidity and strength.

Russell Manufacturing Company, 814 Bath Avenue, Niagara Falls, N. Y.—This company is distributing a vest pocket memorandum book which contains, in addition to the memorandum features, some of the advantages claimed for the Trigger-Lock reversible controller fingers, as well as an explanation of how to install them.

A. W. Cadman Manufacturing Company, Pittsburgh, Pa.—Engineering Bulletin M-1 entitled "Cadman Metals" covers a digest of sixty years' pioneer work in the development of bearing metals. After discussing the requirements of a bearing metal this bulletin takes up various properties of the Cadman metals, such as hardness and compressive strength, relative wear, coefficient of friction, ability to hold an oil film under adverse conditions, plasticity, ability to carry the load at normal temperatures, ease of pouring and handling, uniformity, tensile strength and bonding properties and use in die casting.

Bussmann Manufacturing Company, St Louis, Mo.—An attractive booklet entitled, "Buss Renewable Fuses," illustrates and mentions the principal points and advantages claimed for the Buss fuse. The carefully prepared illustrations in two colors show these points almost as well as the printed descriptions.

The Ohio Electric and Controller Company, Cleveland, Ohio—A small folder describes Ohio motors for shop equipment. Particular attention is given to the use of this motor with the Burke bench drill.

Crown Die and Tool Company, 555 West Monroe Street, Chicago, Ill.—A 24-page booklet, No. 1122, describes the Crown easy cutting pipe dies and labor-saving pipe tools, including pipe vises, portable vise stand, stocks, reamers, cutters and special pipe or conduit bending equipment.

H. Gerstner & Sons, Dayton, Ohio—Catalog No. 3 entitled, "High Grade Tool Cases and Chests," describes a variety of this equipment for the up-to-date mechanic, toolmaker, machinist, and other skilled industrial workers. Some of these cases are portable, while others are larger and heavier for bench use.

New Uses of Electric Steam Boilers

(*Continued from page 405*)

go to waste. These mills need a certain amount of steam during the winter and some of them during the entire year for process work. In such cases the additional power for producing this heating and process steam electrically can be obtained at a small cost thus making the mill's operation practically independent of coal.

There are a number of plants and institutions where a small quantity of steam or hot water is required only at intervals. If a coal-fired boiler is used, it must be kept banked and in service ready to furnish this steam. The greater part of the fuel is consumed while the boilers are standing idle. In such cases electric power can often be purchased for the production of steam or hot water at less cost than it can be made with coal.

It is also true that in some cases the demand charges are too high to permit the use of electric boilers, but a careful comparison of the two methods of making steam should be made.

Twenty-Three Installations of Electric Boilers in Industrial Plants

Company	Number Boilers Installed	Rating of Each Boiler	
		Kw.	Boiler Hp.
Metropolitan District Water Commission, Clinton, Mass.	1	30 to 40	3 to 4
Frank & Lochner, Buffalo, N. Y.	1	100	10
Purity Wool Preparing Co., Peterborough, N. H.	1	130	13
Northern New York Utilities, Inc., Watertown, N. Y.	1	150	15
	1	1,000	100
Millers Falls Paper Co. Millers Falls, Mass.	1	350	35
Cascade Inn, Shawinigan Falls, P. Q., Canada	1	350	35
Niagara Falls (N. Y.) Power Co.	1	18,000	1,800
	1	1,000	100
Canadian Electro Products Co., Shawinigan Falls, P. Q., Canada	2	1,300	130
Montreal Cotton Co., Valleyfield, P. Q., Canada	2	1,500	150
Rochester Gas & Electric Corp., Rochester, N. Y.	1	3,000	300
Ontario Paper Co., Thorold, Ont., Canada	1	3,000	300
Ford Motor Co., Green Island, N. Y.	1	3,200	320
Wayagamack Pulp & Paper Co., Three Rivers, P. Q., Canada	1	5,000	500
Canadian Electro Products Co., Shawinigan Falls, P. Q., Canada	2	5,000	500
Washington Pulp & Paper Co., Port Angeles, Wash.	1	5,000	500
International Paper Co., Niagara Falls, N. Y.	1	6,000	600
U. S. Aluminum Co., Pittsburgh, Pa.	1	5,000 to 7,000	500 to 700
Price Bros. & Co., Kenogami, Canada	1	7,000	700
St. Maurice Lumber Co., Three Rivers, P. Q., Canada	1	12,000	1,200
Oxford Paper Co., Rumford, Me.	1	16,000	1,600
Brown Co., Berlin, N. H.	1	18,000	1,800
Belgian Industrial Co., Ltd., Shawinigan Falls, P. Q., Canada	1	20,000	2,000
Laurentide Co., Grand Mere, P. Q., Canada	2	25,000	2,500